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NASA's FISCAL YEAR 1992 BUDGET OVERVIEW

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BEFORE THE

SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE

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NASA's FISCAL YEAR 1992 BUDGET OVERVIEW

FRIDAY, APRIL 19, 1991

U.S. SENATE,
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY,
AND SPACE OF THE COMMITTEE ON COMMERCE,
SCIENCE, AND TRANSPORTATION,
Washington, DC.

The subcommittee met, pursuant to notice, at 9:02 a.m., room SR–253, Russell Senate Office Building, Hon. Al Gore (chairman of the subcommittee) presiding.

Staff members assigned to this hearing: Steve Palmer, senior professional staff member; and Louis Whitsett, minority professional staff member.

OPENING STATEMENT OF SENATOR GORE

Senator GORE. The hearing will come to order. Welcome to all our guests and witnesses. You all go ahead and join us at the witness table.

We are going to ask both of you to appear simultaneously, and I will have an opening statement and then recognize Senator Pressler. We then will go to Norman Augustine and Admiral Truly.

The American people have come to accept the fact that gaining access to space is both difficult and demanding. In the last three decades, the U.S. civil space program has had its share of failures and disappointments, making us keenly aware that it relies heavily upon the world's most advanced technology.

Yet at the same time, NASA's many more spectacular successes, sending men to the Moon and unmanned probes to the farthest reaches of our solar system, have raised public expectations about the likelihood of our future success in space.

Unfortunately, of course, when success then proves elusive, those expectations sometimes come crashing down, bringing with them much of the support for investing billions of tax dollars in the NASA budget.

Thus was the setting last year, when after the Hubble space telescope problems, and a series of elusive hydrogen leaks which temporary grounded the fleet of space shuttles, the Advisory Committee on the Future of the U.S. Space Program was created.

Given a broad charter to review all aspects of the Civil Space Program, the so-called Augustine Committee was asked to report back in 120 days on its findings and recommendations for shaping the future direction of the U.S. space program.

And I will say before you do, that this is not the official title of the advisory committee. It has been called that, over and above the

strenuous objections of its chairman. But that is what we call it, and Mr. Augustine, you might as well give up on protesting that. [Laughter.]

But very simply, the Augustine Committee provided a coherent framework under which NASA and the Congress could begin to guide the Civil Space Program. The advisory committee established very specific priorities among NASA's many programs.

Most notably, it recognized that within a balanced civil space program, space science must be maintained as the highest priority.

In response to many complaints about the vagaries of the congressional funding process for NASA, the Augustine Committee also established what it believed to be the ideal level of funding for the Civil Space Program throughout the remainder of this decade.

Specifically, the committee concluded that NASA's program be structured so as not to exceed a funding profile containing approximately 10 percent real growth per year. In this era of fiscal restraint, even this is a decidedly ambitious target, and the committee built flexibility into its recommendations, adopting a go-as-you-pay approach for many of NASA's programs.

It is in this environment that NASA prepared the fiscal year 1992 budget. As most everyone knows, the 1992 budget request for NASA totals more than $15.7 billion which is a 13.6-percent increase over the current year appropriation level.

According to Admiral Truly, this request represents a "prudent budget" and "a sobering assessment of the resources required to implement the Civil Space Program."

At the same time, the Administrator will assert today in his testimony that this budget "reflects congressional guidance to temper the rate of growth the NASA budget and responds to the recommendations" of the Augustine Committee.

And, of course, we have had not only the Augustine Committee, but also the 5-year budget agreement, and also the guidelines from the Appropriations Committee. These cross currents and pressures are extremely difficult for any administrator to deal with, and we certainly recognize and acknowledge what a difficult task NASA management has had in responding to all of these pressures.

But the Augustine Committee's advice, I believe, and I think most people agree, was unusually helpful advice and this hearing will help us determine to what extent NASA is really following that advice.

It is an opportunity to determine as well whether the NASA budget request accomplishes this difficult but important task, for the realities of more limited resources in the coming years are absolutely unavoidable given the 5-year budget agreement reached last year between the President and the Congress.

So, we have to develop a plan for structuring the recommendations of the Augustine Committee as well as NASA's ambitious designs within that constrained budgetary framework. To continue to ignore this fact will simply lead us further down the road of stretched out program schedules, delayed missions, and further frustrations with NASA and our space program.

It is time for a new day. The Augustine Committee recognized this situation when it concluded that NASA is currently oversubscribed in terms of the projects it is now pursuing.

In short, NASA is trying to do too much. The Augustine Committee—and that hurts to say that, because all of us want NASA to do more, but given the limitations in resources we simply have to acknowledge them and set some tough priorities.

I think we should set them according to the Augustine Committee's advice, because it expressed the need to prioritize NASA's space programs, ensuring that programs like the Mission to Planet Earth continue to receive needed funding, while those programs that fit into the Mission from Planet Earth such as the space station and other exploration programs be performed on a go-as-you-pay basis.

We are fortunate to have with us today both Norman Augustine, who will highlight of course the recommendations of the Advisory Committee on the Future of the U.S. Space Program, to use its official name; and Adm. Richard H. Truly, Administrator of NASA.

Together, these two distinguished witnesses allow us the opportunity to better understand the Augustine Committee recommendations, while at the same time evaluating NASA's efforts to implement those recommendations within the fiscal constraints under which the Federal Government must now function.

This year we do have a unique opportunity to establish a foundation for a long-term political consensus on NASA's future agenda, by ensuring that it is matched to a level of funding that Congress can sustain.

On the one hand the Augustine Committee articulated what a possible future agenda ought to look like. Yet on the other hand, the budget agreement provides very real spending limitations.

I do not presume that the recommendations of the Augustine Committee and the suggested funding profiles articulated by the Appropriation Committee are absolute, far from it.

Yet, if we can establish a plan that integrates the priorities of the Augustine Committee into existing budgetary limitations, I am convinced we will enhance NASA's effectiveness, public support for it, and the long-term success of the Civil Space Program.

I firmly believe this approach is essential, for if the United States is retain its leadership position in our ever changing world, we have to invest in our future and NASA must continue to be in the forefront of that effort.

Senator Hollings.

OPENING STATEMENT OF SENATOR HOLLINGS

The CHAIRMAN. In recent years, this committee, and the Congress as a whole, have strongly supported growth in the NASA budget. Last year, NASA received a 13.5-percent increase over the fiscal year 1990 funding level. That is approximately the same level of increase that the President has requested for NASA for fiscal year 1992.

The problem that we must confront with respect to this budget request, however, is the extremely constrained fiscal environment in which we now find ourselves. Right to the point, the Federal Government does not have the necessary resources for NASA to pursue each of the major initiatives now underway and currently in planning. There is great merit in the Space Station Freedom, the Mission to Planet Earth, the proposed new expendable launch vehi-

cle, and many of the other programs currently administered by NASA. However, with our current fiscal situation in mind, priorities must be established to ensure that the overall objectives of the U.S. civilian space program are ultimately fulfilled.

Admiral Truly, I look forward to working with you and Mr. Augustine throughout this year. I will do what I can to be supportive. However, I urge you to begin looking at your budget request, as well as the agency's overall program, to ensure that the essential elements of our space program can be preserved within the limitations of the Federal budget. Otherwise, reduced spending allocations that may be required for fiscal year 1992 could have a devastating effect on NASA and the future of the civilian space program for many years to come.

Thank you.

Senator GORE. Thank you, Mr. Chairman. Senator Pressler.

OPENING STATEMENT OF SENATOR PRESSLER

Senator PRESSLER. Thank you, Mr. Chairman for holding this hearing on the findings of the Advisory Committee on the Future of the U.S. Space Program, and on NASA's budget request for fiscal year 1992.

Last year was a difficult period for NASA. In rapid succession, NASA experienced a series of well-publicized problems with the Hubble space telescope, the design of the space station, the fuel leaks in two of the three shuttle orbiters.

Among some there was a momentary loss of confidence in the greater space program in the history of the world. Some difficult and painful questions were asked during this period, as you have mentioned, Mr. Chairman, about the goals, priorities, and management of our civil space program.

Rather than evade these issues, NASA and the Bush administration met them head on. Last August, NASA Administrator Richard Truly and Vice President Quayle chartered the advisory committee you mentioned to do a comprehensive evaluation of the U.S. space program.

They selected as its chairman Norman Augustine, who is here today, the distinguished CEO of Martin Marietta. Then they filled out the panel with the best and brightest from the civil space community.

After interviewing hundreds of aerospace witnesses from industry, academia, and Government, the Augustine panel produced a report that provided decisionmakers with a clear, concise blueprint for the future U.S. space program.

Many of the report's recommendations had been voiced before, but never so boldly. The report to the need for a down-scaled space station which took into account budgetary and engineering realities.

The report advised us that man-tended shuttle was overworked, and that extensive demand on the shuttle fleet should be shared by a new heavy lift launch vehicle. The report covered virtually every one of the major civil space issues that have been vigorously debated in Congress, Government, and the media in recent years.

Of all the recommendations the one that impressed me the most was the panel's endorsement of NASA's Mission to Planet Earth, NASA's contribution to the U.S. global change research program.

On Tuesday this subcommittee heard alarming evidence from NASA that ozone depletion is occurring twice as rapidly as scientists had expected. This erosion will expose the globe to greater levels of ultraviolet radiation, which is known to cause skin cancer, cataracts, and crop damage.

Mission to Planet Earth will apply our satellite technology to understand ozone depletion, global warming, and other global climate threats to mankind.

I am proud that South Dakota's EOS Data Center has been selected to participate in this program. The Sioux Falls based center will be used to archive much of the unprecedented volume of data so that the data is made available to researchers around the country.

I must say, however, that I was distressed by a GAO report released last November which found that NASA had not archived data from some of its most important missions. The report stated that for 23 out of 37 important scientific missions, less than 60 percent of the required data was archived and made available for future investigations.

Thus, we are losing at least 40 percent of that critical data. Given the time and effort spent on our space science missions, it is clear more resources must be spent on data archiving. Maybe Mr. Augustine or Admiral Truly can address this issue briefly during this hearing.

In any event, I do intend to pursue the data archiving problem at next week's Space Subcommittee hearing on NASA's space science programs.

Mr. Chairman, let me finish by welcoming our distinguished witnesses, and expressing my admiration for the leadership and direction they have given our space program. I look forward to hearing their testimony.

Thank you, Mr. Chairman.

Senator GORE. Thank you, Senator Pressler.

Senator Bryan.

Senator BRYAN. Thank you very much, Mr. Chairman.

I have been impressed with the report and the recommendations of the Augustine Committee and I will be anxious to hear from Mr. Augustine himself. So, I will defer any further comment until the round of questions.

Senator GORE. Very good. We will hear your statement, Mr. Augustine, first, and then we will hear from Admiral Truly. Then we will have questions for both of you while you are both at the table to have a dialog about where we go from here.

So, welcome back. I was proud to join Congressman George Brown on the House side when he assigned his committee the No. 1 priority of the year of hearing from your report. We were also pleased to host you and several members of your committee in this very room, just on the eve of the report's release to go over the findings.

We appreciated the courtesy that you and your colleagues on the committee showed us, not only on that occasion, but on several

prior occasions during your deliberations. I have said publicly before, and I will just briefly repeat the sentiments now, that this committee was truly an unusual one in that it has made a tremendous difference. Contrary to the expectations of some, maybe they did not know you as well as some, but contrary to some expectations you all really dug in and got to the core of most of the problems that need to be wrestled with, and came up with a blueprint that really does still have the chance to be the basis for consensus.

We are glad to hear this formal update and presentation here, and then hear from Admiral Truly.

Norm, please proceed.

STATEMENT OF MR. NORMAN AUGUSTINE, CHAIRMAN AND CEO, MARTIN MARIETTA CORP., BETHESDA, MD

Mr. AUGUSTINE. Thank you, Mr. Chairman, and members of the committee. I do appreciate the chance to appear before you this morning and speak with you about the work of the Advisory Committee on the Future of the U.S. Space Program.

I should probably note that ours was the easy part. The tough part is making it all happen, which falls, of course, to Admiral Truly and NASA and others in the administration and the Congress.

With your committee's permission, Mr. Chairman, I would like to submit for the record a formal statement and then briefly summarize it here so that it will leave more time for your questions.

Senator GORE. Without objection. We will do that.

Mr. AUGUSTINE. Thank you.

I should also point out that I, of course, am but 1 of the 12 members of our committee and I am very indebted to the other 11 members for a great deal of time and effort and thought that they put into our work. They were not able to be with me today, but I will do my best to reflect their views.

Our committee did reach unanimity on the issues on which we dealt, with one exception, where I chose to recuse myself because of a conflict of interest. We completed our work December 17 of last year. A great deal, of course, has transpired since that time.

Our committee has not met, and in fact, legally it is no longer in existence. So, we have not met since December 17. That will somewhat limit me in my ability to reflect on events since that time, other than as they affect our findings. I will do my best to do that.

Since we completed our work we had the opportunity to meet with the Space Council and speak to them about our views. We also had the opportunity to spend a good deal of time with the leadership of NASA in a rather informal environment to share with them what we were really trying to say and try to clarify any issues where there might be confusion.

It is my understanding that NASA is conducting a rather thorough review of our findings and from my own impression, NASA's attitude in dealing with the suggestions we have made has been just more than constructive. I would say it has been very positive and open. I remain optimistic that we may be able to have a beneficial affect.

NASA, and I am sure Admiral Truly will speak to this, has asked the advisory committee, which is their permanent advisory committee, to carry on providing independent oversight of the implementation of our committee's findings. That, to me, seems to be a very good process that is working well.

I would like to summarize our principal findings. I am aware that your committee is familiar with our report. The broadest question we were asked is, What should NASA's role be in the Civil Space Program and should it be changed?

For example, should the shuttle be operated by a commercial or other Government or quasi-Government agency? Should the Mission from Planet Earth, the SEI, the space exploration initiative, be conducted by some other new organization?

It was our conclusion that none of the changes of that type were appropriate. As one conducts, I think, a reasonably objective review of the capabilities of the various organizations to conduct space programs, it is really a fact that there is no organization in the world, no single organization in the world that has the capability that NASA has. And so we concluded that the right thing to do was to try to help make NASA better and better. That was our focus.

We offered five principal objectives for our space program in the future. The intent was to conduct a balanced space program. We were careful not to prioritize these objectives, 1, 2, 3, 4, 5, because when one does, there is a danger of one winds up with all the money on No. 1 and that was not our intent. On the other hand, some things did seem to us more important than others and I will try to suggest those as we go.

The one that did seem most important to us, certainly the highest overall priority in a balanced space program, would be the science program. It is the space science program that really underpins everything we do in space. It is the science program that has the principal impact on education. It helps America's competitiveness. And it is really the essence of the space program in our judgment.

There were two major missions accompanying the science program that we have endorsed. The first of those is the Mission to Planet Earth that Sally Ride some years ago with her committee identified and named. That is the mission that will help us better bring the capabilities of space down to Earth, to understand life here on Earth, particularly to understand our environment and to help assure that we do not damage it further and perhaps we can undo any damage that has been done.

The third element of our five goals for the space program is what we chose to call a Mission from Planet Earth. We chose that name to indicate some sense of balance for the Mission to Planet Earth. The Mission from Planet Earth is where the manned space activity would principally reside. It has several steps toward its ultimate goal. And that ultimate goal would be to place humans on Mars.

Of course, it will be many years before men and women can walk on Mars and there is much to be done before that. The first step is the space station, which is the critical next step if America is to have an effective humans in space program. We can speak more of that in your questions, if you wish.

The fourth goal we identified and the fifth goal have to do with might be called housekeeping. And I do not use that in a demeaning sense.

The fourth has to do with the technology base, which really underpins our space program in terms of developing components and engineering capabilities that make it all possible. That program has been allowed, in our judgment, to atrophy for some years, for 2 decades in fact, and places it in danger that we might, in the future, have to undertake rather major missions without the technical building blocks being in place. And that has traditionally been a mistake when we have found ourself in that predicament.

We believe that greater attention is required to the technology base, which admittedly is not a very glamorous part of the space program.

Last, the matter of providing transportation to near-Earth orbit, particularly to near-Earth orbit, seemed to us to be something that deserved some attention. The space shuttle is an important capability. In fact, it is our only major capability for the Civil Space Program for the rest of the decade. And we must do everything we can to make the shuttle as resilient and as reliable as we can.

On the other hand, it struck us that it was not wise to be that dependent for the whole civil space program, virtually the whole civil space program, on a single launch system, particularly one as complex as the shuttle. And for that reason we have encouraged that an additional unmanned launch vehicle be built which could someday be man ratable. This could be used to help unburden the space shuttle.

Those were the five principal goals we identified.

In closing my opening remarks, I would like to make two other comments. One is that NASA truly is in a transition period. NASA has, as you alluded to, Mr. Chairman, many projects underway. Our committee found NASA in midstream and some of our recommendations might have been different were we creating a new NASA from whole cloth.

The fact is that there are many projects underway, but unfortunately, in our view, most of those projects have very, very minimal margins, margins in time, schedule, talent, money, technical margins. And that places NASA in a position where it requires almost superhuman management to avoid problems.

Because of that and the other things that need to be done in the space program, an example is initiating a new launch vehicle in our view, the budgetary pressures for a few years will be extremely difficult. And that is the reason we have proposed a growth rate of the level that you alluded to in your remarks, Mr. Chairman.

The second and last comment I would like to make is that our committee views the Civil Space Program truly at a crossroads as we meet here today. The building of a consensus is so important, as to what the goals should be, what the funding level should be, and then to be able to provide stability to the space program.

When one undertakes very, very difficult technical projects, as indeed NASA does routinely, and those projects have a duration of 10, 20, or even 30 years, clearly one has to have stability, particularly stability of funding and goals.

One of the factors that has been absent in the Civil Space Program, in our view, since the Apollo Program was such stability. We need to build a consensus in this country on some program, whatever that program might be. And then to provide NASA the resources and the opportunity to carry that program out. That will require some compromise on all of our parts and many of the various parties involved in the space program have been unfortunately unwilling to compromise in the past. I think that has been damaging to the space program.

That summarizes what I would like to say, Mr. Chairman. I would be very happy to answer yours or the committee's questions.[The prepared statement of Mr. Augustine follows:]

PREPARED STATEMENT OF MR. NORMAN R. AUGUSTINE

REPORT OF ADVISORY COMMITTEE ON THE FUTURE OF THE U.S. SPACE PROGRAM

Executive Summary

The United States' civil space program was rather hurriedly formulated some three decades ago on the heels of the successful launch of the Soviet Sputnik. A dozen humans have been placed on the Moon and safely returned to Earth, seven of the other eight planets have been viewed at close range, including the soft landing of two robot spacecraft on Mars, and a variety of significant astronomical and other scientific observations have been accomplished. Closer to Earth, a network of communications satellites has been established, weather and ocean conditions are now monitored and reported as they occur, and the Earth's surface is observed from space to study natural resources and detect sources of pollution.

Problems and Perspectives. In spite of these virtually unparalleled achievements, the Civil Space Program and its principal agent, the National Aeronautics and Space Administration, are today the subject of considerable criticism. The source of this criticism ranges from concern over technical capability to the complexity of major space projects; from the ability to estimate and control costs to the growth of bureaucracy; and from a perceived lack of an overall space plan to an alleged institutional resistance to new ideas and change. The failure of the Challenger, the recent hydrogen leaks on several Space Shuttle orbiters, the spherical aberration problem encountered with the Hubble Space Telescope, and various launch processing errors such as a work platform left in an engine compartment and discovered during launch preparations, have all heightened this dissatisfaction.

Some of the concern is, in the view of the Committee, deserved and occasionally even self-inflicted. For example, the practice of separately reporting the cost of space missions according to accounting categories (which for bookkeeping purposes allocates launch services to a distinct account) results in confusion as to what is the actual cost of a mission.

Yet, in spite of recognized current problems, care must also be taken not to impose potentially disruptive remedies on today's NASA to correct problems that existed in an earlier NASA. The much publicized spherical aberration problem of the Hubble Space Telescope encountered this past year is in fact a consequence of an assembly error left undiscovered in tests conducted a decade ago—in 1980. The decision to launch the Challenger in cold weather, when the seals between rocket motor segments would be most suspect, took place five years ago and has spurred NASA to many management changes. Since the Challenger accident, NASA has increased the emphasis on safety, and has borne the burden of delaying launches when reasonable questions arose over the readiness to launch safely. On the other hand, processing incidents during launch preparation continue to occur in NASA operations, and to be the cause of justifiable concern.

Because of the intense interest in—and scrutiny of—America's commendably open and visible civil space program, it is sometimes easy to overlook the fact that technical problems such as hydrogen leaks, faulty seals and erroneous assembly procedures are not unique to today's space activities, or even to NASA. Although problems of any sort are emphatically not to be condoned, when comparing today's space program with the successes of the past, it must also be recalled that America's first attempt to launch an Earth satellite using the Vanguard rocket ended in failure. By the end of 1959, 37 satellite launches had been attempted: less than one-third attained orbit. Ten of the first eleven launches of unmanned probes to the Moon to obtain precursor data in support of the Apollo mission failed. Three astronauts were

lost in a fire aboard the Apollo capsule during ground testing. A cryogenic storage tank exploded during the mission of Apollo XIII en route to the Moon, seriously damaging the spacecraft. During the few months surrounding the Challenger accident, a Delta, an Atlas-Centaur, two Titan 34-D's, a French Ariane-2 and a Soviet Proton were all lost.

Space missions, whether manned or unmanned, are fundamentally difficult and demanding undertakings that depend upon some of the world's most advanced technology. The Saturn V rocket required the integration of some six million components manufactured by thousands of separate contractors. Voyager 2 arrived at Neptune a mere one second behind its final updated schedule after a 12-year, 4.4 billion mile flight, approaching within 3,000 miles of the planet's surface. The information to be gathered by the Earth Observing System could approach 10 trillion bits of information—about one Library of Congress. The matter of human frailty is perhaps of even greater import: in the case of the Apollo program, some 400,000 people at some 20,000 locations were involved in its design, test and operation.

Concerns. Nonetheless, given the cost of space activities, in both financial and human terms, and their profound impact on America's prestige throughout the world, no goal short of perfection is acceptable. The Committee finds that there are a number of concerns about the civil space program and NASA which are deserving of attention.

The first of these is the lack of a national consensus as to what should be the goals of the civil space program and how they should in fact be accomplished. It seems that most Americans do support a viable space program for the nation—but no two individuals seem able to agree upon *what* that space program should be. Further, those immediately involved in the program often seem least inclined to compromise for the common good. Some point out that most space missions can be performed with robots for a fraction of the cost of humans, and that, therefore, the manned space program should be curtailed. Others point out that the involvement of humans is the very essence of exploration, and that only humans can fully adapt to the unexpected. Some point to the need for accelerated commercialization of space while others argue the benefits of fundamental science—only to be challenged in turn to prove the tangible value of studies in astronomy.

Second, and closely related to this contentious yet fundamental matter, our Committee believes that NASA is currently overcommitted in terms of program obligations relative to resources available—in short, it is trying to do too much, and allowing too little margin for the unexpected. As a result, there is the frequent need to revamp major programs, which in turn sometimes results in forcing smaller (scientific) pursuits to pay the bill for problems encountered in larger (frequently manned) missions. Of major importance, in our view, is the fact that margins needed to provide confidence in maintaining cost, schedule, performance, and especially reliability, too often are minimal or absent.

Third, continuing changes in project budgets, sometimes exacerbated by actions needed to extricate projects from technical difficulties, result in management inefficiencies. These demoralize and frustrate the individuals pursuing those projects—as well as those who must pay the bills.

Fourth, there is the matter of institutional aging and the concern that NASA has not been sufficiently responsive to valid criticism and to the need for change.

Fifth, the personnel policies embodied in the civil service system are, in the opinion of the Committee, hopelessly incompatible with the long-term maintenance of a leading-edge, aggressive, confident, and able work force of technical specialists and technically trained managers that will be needed by NASA in the years ahead.

Sixth, it is a natural tendency for projects to grow in scope, complexity, and cost. Deliberate steps must be taken to guard against this phenomenon if programs are not to collapse under their own weight—often, as already noted, taking a toll on the smaller projects that must share in the budget.

Seventh, the material foundation of any major space project is its "technological base." It is this base that produces the key building blocks, or "enablers," that make major missions possible—new materials, electronics, engines and the like. The technology base of NASA has now been starved for well over a decade and must be rebuilt if a sound underpinning is to be regained for future space missions.

Eighth, space projects tend to be very unforgiving of any form of neglect or human failing—particularly with respect to engineering discipline. Spacecraft incorporating flaws are not readily "recalled" to the factory for modification. It is this category of problem that has evoked much of the criticism directed at NASA in recent years, although with new technology there are growing opportunities for systems that are "self-healing."

Finally, ninth, the civil space program is overly dependent upon the Space Shuttle for access to space. The Space Shuttle offers significant capabilities to carry out mis-

sions where humans are uniquely required—as has been the case on a number of occasions. The Shuttle is also a complex system that has yet to demonstrate an ability to adhere to a fixed schedule. And although it is a subject that meets with reluctance to open discussion, and has therefore too often been relegated to silence, the statistical evidence indicates that another Space Shuttle is likely to be lost in the next several year * * * probably before the planned Space Station is completely established on orbit. This would seem to be the weak link of the civil space program unpleasant to recognize, involving all the uncertainties of statistics, and difficult to resolve.

The Space Shuttle differs in important ways from unmanned vehicles—on the positive side it provides the flexibility and capability attendant to human presence and it permits the recovery of costly launch vehicle hardware which would otherwise be expended. On the negative side, it tends to be complex, with relatively limited margins; it has not realized the promised cost savings; and should it fail catastrophically, it takes with it a substantial portion of the nation's future manned launch capability and, potentially, several human lives.

The Committee recognizes the important role of the Space Shuttle for missions where there is the need for human involvement, and notes that the Space Shuttle is absolutely essential to America's civil space program for the next decade or more. Necessary steps to assure the viability of Space Shuttle operations this decade should therefore proceed. Nonetheless, the Committee believes *in hindsight* that it was, for example, inappropriate in the case of Challenger to risk the lives of seven astronauts and nearly one-fourth of NASA's launch assets to place in orbit a communications satellite.

Agency Responsibilities. Against the backdrop of these and other concerns, the Committee was asked to consider whether some altogether new form of management structure should be established to pursue portions of the nation's civil space program, as has been recommended by various observers. Such a model might include an altogether separate agency patterned after, say, the Strategic Defense Initiative Organization of the Department of Defense, which would be established to pursue major new initiatives such as the Mars exploration program. Another possibility occasionally proposed is to separate the Space Shuttle's operation from NASA so as to permit the space agency to focus upon the pursuit of advanced technology and new leading-edge missions.

The conclusion of the Committee is that changes of such sweeping scope are inappropriate. First, in spite of imperfections, by far the greatest body of space expertise in any single organization in the world resides within NASA. Further, in the case of Space Shuttle operations, the maturity of the system is neither compatible with a (potentially disruptive) shift to a new operator nor, in the opinion of the Committee, is it ever likely to be—even though in principle we favor private sector operations over government operations whenever practicable. NASA and its predecessor, NACA, have followed this practice with regard to the aeronautics program—producing unmatched technology that helped make America's commercial aircraft industry preeminent in the world. A similar effort is needed with respect to space activities—but the Space Shuttle is not, in our opinion, the correct mechanism for accomplishing this objective.

Briefly stated, the Committee believes that NASA, and only NASA, realistically possesses the essential critical mass of knowledge and expertise upon which the nation's civil space program can be sustained—and that the task at hand is therefore for NASA to focus on making the self-improvements that gird this responsibility.

A Space Agenda. The question then arises: "What should be the U.S. space program?" Although it may be tempting to lay out an accelerated plan to accomplish the unaccomplished and to attack the unknown, to do so in the absence of fiscal and technical realism would be a disservice, and would only magnify the problem of management "turbulence" that already has been so costly to the space effort—both in money and morale.

The question thus becomes one of what can and should the U.S. afford for its civil space endeavors in a time of unarguably great demands right here on Earth, ranging from reducing the deficit to curing disease and from improving education to eliminating poverty. The answer to this question is made all the more difficult because the space program touches so many aspects of our lives and contributes to the accomplishment of goals ranging from improving education to enhancing our standard of living and from assuring national security to strengthening communications among the peoples of the world. The space program produces technology that enhances competitiveness; the largest rise and subsequent decline in the nation's output of much needed science and engineering talent in recent decades coincided with, and some say may have been motivated by, the build-up and subsequent phase-down in the civil space program.

Global understanding has been enhanced through the establishment of widespread satellite telecommunications. Countless lives and considerable property have been saved through advanced weather forecasting and the use of spaceborne search and rescue systems. Basic scientific knowledge has been obtained that addresses such important questions as why one planet evolves to become altogether uninhabitable, while another nurtures life.

It can be argued that at least some of these benefits can be reaped by other more direct means. If the objective is to stimulate education, then why not give the money being spent on space to our schools? If the objective is to study the stars, then why not build more and better telescopes here on Earth? To ease poverty, give aid to those in need. Yet perhaps the most important space benefit of all is intangible—the uplifting of spirits and human pride in response to truly great accomplishments—whether they be the sight of a single human orbiting freely around the Earth at 18,000 miles per hour, or a picture of Uranus' moon Miranda transmitted 2.8 billion miles through space, and taking a little over four hours merely to arrive at our listening stations even when traveling literally at the speed of light. Such accomplishments have served to unite our nation, hold our attention, and inspire us all, particularly our youth, as few other events have done in the history of our nation or even the world.

Our Committee concludes that America does want an energetic, affordable and successful space program, a predilection to which we as individuals unabashedly confess. This support has been evidenced in the gradual growth in space funding for nearly two decades (Figure 1). The question remains, however, "What *should* we afford?" In this regard, a historical perspective is helpful. At its peak, during the Apollo years, America spent 0.8 percent of its gross national product on its civil space program (Figure 2). This level amounted to about 4.5 percent of federal spending at the time (Figure 3) and, perhaps more importantly, about 6 percent of the discretionary portion of the federal budget (Figure 4). Today, we as a nation are spending about one-third of the Apollo peak spending as a portion of the GNP—and the fraction of the increasingly pressured total discretionary budget has declined to 2.5 percent.

Presumably reflecting public support, both the Executive Branch and the Congress have recently shown a willingness to increase civil space spending on the order of 10 percent per year (real growth) for a well-executed program. This, therefore, is the baseline selected by this Committee to assure at least a first order fiscal test in our proposals. A larger budget would obviously permit a more energetic space program—while the converse also is true. We recommend an approach which can accommodate, *within limits,* either contingency. Our specific assumption is that the civil space budget will grow by *approximately* 10 percent per year in real dollars throughout most of this decade, leveling out at about 0.4 percent of the GNP. This is a budget that can enable a strong space program—but only if funding is predictable and programs are carefully managed and consistently executed. As a reference, civil space spending recently approved for 1991 represented 8.5 percent real growth over the prior year's spending.

In defining a space agenda we believe it is not sufficient merely to list a collection of projects to be undertaken in space, no matter how meritorious each may be. It is essential to provide a logical basis for the structure of the program, including a sense of priorities.

A Balanced Space Program. It is our belief that the space science program warrants highest priority for funding. It, in our judgment, ranks above space stations, aerospace planes, manned missions to the planets, and many other major pursuits which often receive greater visibility. It is this endeavor in science that enables basic discovery and understanding, that uncovers the fundamental knowledge of our own planet to improve the quality of life for all people on Earth, and that stimulates the education of the scientists needed for the future. Science gives vision, imagination, and direction to the space program, and as such should be vigorously protected and permitted to grow, holding at or somewhat above its present fraction of NASA's budget even as the overall space budget grows.

Having thus established the science activity as the fulcrum of the entire civil space effort, we would then recommend the "mission-oriented" portion of the program be designed to support two major undertakings: a Mission *to* Planet Earth and a Mission *from* Planet Earth. Both, we believe, are of considerable importance. The Mission *to* Planet Earth, as we would define it, is the undertaking that in fact brings space down to Earth—addressing critical, everyday problems which affect all the Earth's peoples. While we emphasize the need for a balanced space program, it is the Mission to Planet Earth which connotes some degree of urgency. Mission to Planet Earth, as we would define it, comprises a series of Earth-observing satellites, probes and related instruments, and a complementary data handling system

aimed at producing a much clearer understanding of global climate change and the impact of human activities on Earth's biosphere. This effort will provide us with a much better understanding of our environment, how we may be affecting it, and what might be done to restore it.

The Mission *from* Planet Earth is principally, but not exclusively, focused upon the exploration of space. This is where most of the manned space undertakings are to be pursued and as such this tends to be the most costly aspect of the civil space program.

Today, America's manned space program is at a crossroads. The Committee believes that a focus must be given to this program now if it is not merely to drift through the decade ahead. Although there is no particular timetable that can in good conscience be assigned to this pursuit, it nonetheless sorely needs agreement as to direction.

At least in part because of its cost, the manned space program has been at the very hub of controversy swirling around the nation's civil space activity. It can be argued that much of what humans can perform in space could be conducted at less cost and risk with robotic spacecraft and in many instances we believe it should be.

But are there not activities in space which properly should be the province of human intelligence, flexibility and being? The Committee found it instructive in this regard to ask whether we would be content with a space program that involved *no* human flight. Our answer is a resounding "no." There *is* a difference between Hillary reaching the top of Everest and merely using a rocket to loft an instrument package to the summit. There *is* a difference between the now largely forgotten Soviet robotic Moon explorer that itself returned lunar samples, and the exploits of astronauts Neil Armstrong, Buzz Aldrin, and Mike Collins. The Committee thus wholeheartedly endorses a far-reaching, but we believe realistic, undertaking in manned space activity, carefully paced to the availability of funds.

But if there is to be a manned space undertaking, what should it be? Surely the goal is not merely to provide routine transportation of cargo to and from space. In this regard, we share the view of the President that the long-term magnet for the manned space program is the planet Mars—the human exploration of Mars, to be specific. It needs to be stated straightforwardly that such an undertaking probably must be justified largely on the basis of intangibles—the desire to explore, to learn about one's surroundings, to challenge the unknown and to find what is to be found. Surely such an endeavor must be preceded by further unmanned visits, and by taking certain important steps along the way, including returning for extended periods to the Moon in order to refine hardware and procedures and to develop the skills and technologies required for long-term planetary living.

The Committee offers what we believe to be a potentially significant new approach in the planning of human space exploration. Although we appreciate the arguments for setting a "date certain" for many or even most of our space goals, as did President Kennedy with respect to going to the Moon, we believe that a program with the ultimate, *long-term* objective of human exploration of Mars should be tailored to respond to the availability of funding, rather than to adhering to a rigid schedule. This does not demean the importance of the manned space program, but rather is a consequence of the fact that we simply cannot know with any exactness the cost or obstacles which may impede a Mars mission. We do know that, whatever the cost is, it can be spread over many years, and that it will have to endure the changing emphasis of a series of Presidents and Congresses as well as of economic circumstances. We also believe that this is a challenge that could be constructively shared among a number of nations. The challenge, from a management standpoint, is to tailor a program, the first step of which is to generate needed technology building-blocks, which can adapt to the availability of funds. The availability of funding would then determine mission schedule—because the converse is neither economically nor politically practical. Unforeseen fiscal demands would be borne by the program itself rather than off-loaded to other important but smaller (science) programs.

Using this management approach, the Committee believes that a sound, long-term human exploration program can be pursued. It provides an important companion to Mission to Planet Earth and clearly states America's intention to stay in space with humans.

But fundamental uncertainties remain with respect to the feasibility of long duration human spaceflight, uncertainties that revolve around the effects of solar flares, muscle deterioration due to weightlessness, the loss of calcium in human bone structure, and the impact of galactic cosmic radiation. These basic issues need to be resolved before undertaking vast projects—by means of long-duration operations involving humans in space. We thus arrive at what we believe is the fundamental reason for building a space station: to gain the much needed life sciences information

and experience in long duration space operations. Such information is vital if America is not to abdicate its role in manned spaceflight.

We do not believe that the Space Station Freedom, as we now know it, can be justified solely on the basis of the (non-biological) science it can perform, much of which can be conducted on Earth or by robotic spacecraft for less cost. Similarly, we doubt that the Space Station will be essential as a transportation node—certainly not for many years. However, the Space Station is deemed essential as a life sciences laboratory, for there is simply no Earth-bound substitute. The Space Station is a critical next step if the U.S. is to have a manned space program in the future. At the same time, the Space Station can also provide a capability for important microgravity research, and for practical experience in processing under low-gravity conditions. While not, in our opinion, a sufficient justification of Space Station in and of itself, microgravity research does represent an altogether valid element of America's economic competitiveness program.

Given these conclusions, we believe the justifying objectives of the Space Station Freedom should be reduced to two: primarily life sciences, and secondarily microgravity experimentation. In turn, we believe the Space Station Freedom can be simplified, reduced in cost, and constructed on a more evolutionary, modular basis that enables end-to-end testing of most systems prior to launch, and reduces extravehicular flight requirements along the lines NASA is now considering. We also believe that steps must be taken to mitigate dependence on the Space Shuttle.

Given all of this, we would encourage NASA and the Congress not to be bound by the 90-day restructuring period for Space Station Freedom recently directed by Congress. Redesign is simply too important to take less than whatever time may be needed for a thorough reassessment and the establishment of a configuration that can earn stable, long-term funding support.

Having thus defined a Mission *to* Planet Earth (MTPE) and a Mission *from* Planet Earth (MFPE) as the keystones we recommend for America's future civil space program, there remain two vital elements of space infrastructure to which attention must be devoted. This infrastructure underpins the nation's ability to actually undertake advanced space missions, and is addressed in two parts: first, the technology base, and second, the Earth-to-space transportation system. Great space pursuits should not be undertaken without proper attention being devoted to these more mundane but critical aspects of the space endeavor.

First and foremost in this foundation-laying effort is the technology base which absolutely must be replenished. America has not initiated development of a new main rocket engine—the muscle of any space pursuit—in nearly two decades. Work on advanced space power systems has been modest; on very high specific impulse propulsion devices even more limited, on advanced concepts such as aerobraking only formative. In fact, the overall technical base underpinning the space program has been permitted to languish in terms of funding for several decades. This effort has not, in recent years, enjoyed the support of the Legislative Branch, or, in earlier years, of the Executive Branch. This must be corrected.

The second element of space infrastructure concerns the provision of high-confidence, reasonable-risk transportation to space. In this regard, the U.S. will be unalterably committed to the Space Shuttle for many years hence. Thus, NASA simply must take those steps needed to enhance the Shuttle's reliability, minimize wear and tear, and enhance launch schedule predictability. Cost reductions also are desirable but secondary to the preceding objectives.

We further conclude that NASA should proceed immediately to phase some of the burden being carried by the Space Shuttle to a new unmanned (but potentially man-ratable) launch vehicle that offers increased payload capacity and is derivable wherever practicable from existing components to save time and cost. Presumably, some of these components could be obtained selectively from the Shuttle system itself, including launch facilities. Future enhancements would use elements derived from the Advanced Launch System technology program in progress under the cooperative management of NASA and the Department of Defense. Such an evolving heavy lift launch system should be designed to produce substantial reductions in launch costs; a major, albeit moderately declining, portion of NASA's budget.

It should be recognized that the substantial near-term costs of developing any new heavy lift launch vehicle make a purely financial argument for its existence not particularly compelling. Rather, the objective is to attain a reliable, unmanned vehicle that complements the Space Shuttle and that can be used for routine space trucking, saving the Space Shuttle for those missions requiring human presence. The resulting reduced demand for the Shuttle will help relieve the schedule pressures which have contributed to some of the problems the program has encountered.

Even though selected Space Shuttle components and existing launch facilities might be used for the proposed new launch vehicle, the hazards of coupling failure

modes between these two vehicles can be reduced to what we believe is an acceptable level. In short, we must buttress the civil space program's capacity and means of access to space as soon as possible.

Over the longer term, the nation must turn to new and revolutionary technologies to build more capable and significantly less costly means to launch manned and unmanned spacecraft, including those that one day will travel to the Moon and Mars. However, the type of launch vehicle and the specific operational concept that will be needed to propel spacecraft from the Earth's surface to orbit and on to the Moon and Mars will depend on the results of mission architecture studies now underway. In the meantime, while we await the definition of the future spacecraft and launch vehicle requirements, the nation must maintain a vigorous Advanced Launch System technology program. This program, augmented by new propulsion technologies, will provide the elements to enhance our current and evolving launch vehicle fleet and eventually provide the basis for completely new and revolutionary launch systems.

International Pursuits. NASA's accomplishments over the years in space science and technology have helped motivate other nations to pursue space programs of their own. The success and interests of these new participants in the civil space arena places NASA's role in a somewhat changed context as we approach a new millennium, one where our nation must both cooperate and compete. International cooperation can serve to demonstrate leadership, to forge productive relationships and to broaden the range of available opportunities for accomplishment, as has been shown through a long and successful history of NASA-supported international partnerships. But international agreements can also lead to bureaucratic constraints and delays where many levels of approval are required for each decision. The Committee notes that international commitments must be made carefully, supported by all affected parts of the government prior to consummation, including the Congress, and thereafter honored scrupulously. We emphasize that international cooperation should continue to be an integral part of the U.S. civil space program. But we also emphasize that the U.S. should retain management control for critical in-line program elements in certain long-term undertakings such as human space exploration, and that the U.S. must continue to have a fully competitive stance in areas such as the access to space itself, i.e., launch vehicles which have broad impact on the fundamental viability of America's civil and commercial space programs.

Some Final Observations. This, then, is the space program that our Committee recommends. A number of further recommendations are offered in the text concerning management improvements, and the all-important matter during the years ahead of attracting to and retaining within NASA a share of the nation's most capable people. Organization charts and improved management practices will prove altogether hollow if NASA is not permitted to attract the extraordinary people needed to successfully pursue the energetic goals prescribed herein.

Many of the recommendations we offer deal with the seemingly mundane aspects of the space program—but, in our view, are of no less importance than the higher-impact recommendations we also offer. These recommendations and suggestions are included in the text and address such matters as enhancing cost estimating capabilities; increasing cost, schedule and performance margins; and strengthening systems engineering.

How shall we pay the bills for all of this? First, as already noted, we assume growth in civil space funding for the next decade. We also recommend a redesign of the Space Station, in part, to reduce cost. We would propose diverting funds from the planned additional Space Shuttle orbiter (but not from support hardware needed to assure the Space Shuttle's continued operational viability) to enable construction of the new unmanned heavy lift launch vehicle. We believe that a new unmanned launch vehicle itself can produce substantial savings—but not in the near term and in the longer term only if we change our processing philosophy and manpower. We recommend configuring the long-term manned exploration program, which focuses on Mars but has critical stepping stones along the way in the form of the Space Station and a lunar base, to a schedule that adapts to the availability of funding. And we propose a number of management enhancements that should produce efficiencies and modest attendant cost savings. The most important of this category of improvement, however, is not fully within NASA's wherewithal to implement—namely, the provision of predictable and stable funding. This will require the support of other parts of the Administration and the Congress. The essential role of this support cannot be overemphasized if the U.S. is to have a successful civil space program.

It should also be noted that NASA has a number of other responsibilities to which it must attend. Foremost among these is the continued support of a strong aeronautics program—the linchpin of America's competitiveness in civil aviation. NASA should also continue to help nurture a commercial space industry, as it has in re-

cent years. The Committee is strongly committed to the free enterprise system and believes NASA should do only those things that cannot be satisfactorily performed in the private sector, including academia and industry. There are, of course, many matters which can only be done within the government, including, to name but a few, the pursuit of leading-edge, high-cost research with uncertain or long-term payoff; planning and providing specialized joint-use facilities; and administering contracts and monitoring the performance of contractors.

Finally, in regard to NASA's other responsibilities, we applaud its on-going efforts to enhance the nation's mathematics and science education programs.

We believe that the legacy our generation should leave to the future is that we pioneered the exploration of space, and thereby made important discoveries that will prove of benefit to all mankind. However, space activity is inherently difficult—involving advanced technology and taking place over great distances. It demands reliance upon machines, often very complex machines, which are designed, tested and operated by mortals. It involves rewards which may be intangible.

As we labor under such challenges, we should insist upon excellence. We should strive for perfection. We should demand the utmost of those to whom we entrust our space endeavor. But we should be prepared for the occasional failure. If we as a nation are to place a greater premium on letting nothing go wrong, on not making errors, and on ridiculing those who strive but occasionally fail, than we place upon seeking potentially great accomplishments, then we have no business in space.

Senator GORE. Great. We will explore some of the details of what you have said here in questions. But now we will hear from Admiral Truly.

Welcome again. You have come twice in one week. And we appreciate it very much, Admiral.

STATEMENT OF ADM. RICHARD H. TRULY, ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION; ACCOMPANIED BY, MR. JAMES R. THOMPSON, DEPUTY ADMINISTRATOR, MR. THOMAS CAMPBELL, COMPTROLLER, MR. ARNOLD D. ALDRICH, ASSOCIATE ADMINISTRATOR, OFFICE OF AERONAUTICS, EXPLORATION AND TECHNOLOGY, DR. LENNARD A. FISK, ASSOCIATE ADMINISTRATOR, OFFICE OF SPACE SCIENCE AND APPLICATIONS, AND DR. WILLIAM B. LENOIR, ASSOCIATE ADMINISTRATOR, OFFICE OF SPACE FLIGHT, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Admiral TRULY. Thank you, Mr. Chairman, and thank you for the opportunity to be here at the table with Norm Augustine to discuss what I think is a premier piece of work that the committee that he led achieved.

Over the past few years, there has been great debate about America's Civil Space Program. And as you know, the present administration—that President Bush has put investment in the Civil Space Program at a very high priority. And this past summer we jointly decided, in the conversations between me and the Vice President—private conversations—that it was time to put together a committee of people that were experienced both in public policy and the technical aspects in the science missions of the Civil Space Program across the board. And we did that.

I appointed the committee that Norm Augustine was the chairman of last summer. And they have delivered to NASA, to the White House, and to the Congress, and the Nation, a report that, I believe, is very thorough. It left no stone unturned. And that was what we asked them to do. And it made specific recommendations that are designed to help not only NASA, but other organizations that have to do with the Civil Space Program to make it more ro-

bust and to make sure that America's leadership in space, which we do now enjoy, is continued in the future.

I would point out that the recommendations that are in the committee's report go beyond NASA, but I want to concentrate principally this morning on what we are doing with those recommendations that were directed toward us. Frankly, some of the recommendations of the report are critical of some things that NASA was doing, but I asked the committee to be critical. And the criticism is constructive, and I accept it.

Change is never easy, but we are determined that NASA must change in the future if we are to successfully accomplish the mandate that we have for the programs of the future. And I believe those programs are the right ones and we should continue this investment. To implement this report is going to take more than the support of me and the top NASA management, it is going to take a consensus building that Norm just mentioned, and it is going to take the support of the administration and the Congress, and particularly stable and adequate funding for the program that is selected.

There have been many interpretations of the report. And I think that all of us should continue to reexamine and read it carefully because it is very balanced. It concerns budgets, priorities, personnel, launch systems, space stations, directions, and leadership.

As a result of the report that was delivered in December, I believe, we have, within NASA, developed a very comprehensive implementation plan. And I have a copy of the latest version of it, which is dated yesterday, which we briefed to the NASA advisory council, and with your permission, Mr. Chairman, I would like to offer this status for the record. And I believe that we have provided you with copies of it.

Basically this status takes out of the Augustine report each and every one of the recommendations. And for our own management purposes, allows me to hold monthly meetings to assign actions within the agency. And my goal, quite honestly, is that when 1991 is over, we will have taken action on every one of the recommendations. I am not sure that we will take them all. Some of the implementation may be along the thrust of the recommendation but not precisely as the committee stated it. But we are being very aggressive.

We have closed, already, a number of actions. In the next few months, I think the majority of them will be closed. And by the end of the year, I would like to be in the position to stop tracking action items of the Augustine Committee's recommendations and have them built into the Civil Space Program in an implementable fashion.

I would also like to say that the budget that has been presented by the President for 1992 for the Congress, was significantly impacted by this report in very real ways. Life sciences was given a higher priority in the 1992 budget than it was in the past. As a matter of fact, I believe the percentage of the science program is upward of 23 or 24 percent, where generally in the past it has been around 20 percent.

Life sciences is given a priority in this budget. The Space Station Freedom, which was the subject of your hearing a couple of days

ago, took into account not only the direction from our appropriations bill of 1991, but also the recommendations of the Augustine Committee. And I believe that the restructured space station program is on sound track, and badly needs the support of this committee to go forward.

But there wereother things, as well. The shuttle flight rate was adjusted in the fiscal year 1992 budget to level off at 10 flights per year as opposed to the 12 flights that had been in the previous outyear flight rate plan. And incidentally, on that subject, since we are facilitized with mobile launch platforms and pads and orbiters to 12 a year, I think that we will certainly achieve that flight rate and with some margin.

I did agree, and deferred at least for 1992, the request to build a new orbiter in order to accommodate room in the budget to move out on one of the principal recommendations of the committee, which is a new launch system which will be a joint DOD–NASA program, and is in the proposal to the Congress. Support in the assured shuttle availability program to make sure that the underpinnings of the shuttle were approved for the 1992 budget and were a part of the recommendation of the committee. And the recommendation to move the TDRS, the Tracking and Data Relay Satellite, to an ELV was a direct result of this debate.

At the end, let me also conclude with a couple of personal remarks about the report that the committee gave to NASA and to the Nation. And then I would be pleased, with Norm, to try to answer any questions that you might have either on our interpretation of the recommendations, or our implementation as we go forward.

First of all, let me emphasize a balanced space program. Norm mentioned it in his original remarks. I think that this is a balance report, and the point that he made is very, very important. If all those parties in the Civil Space Program, including NASA, the Congress, the science community, the transportation community, are unwilling to compromise, and are only willing to take out of this report the sentence that supports their side of the program, I think that we will have failed.

I think that drawing together to a consensus as to the goals and implementation of the Civil Space Program is now within our grasp. And it will be based on the work of the individuals on this committee that put down, I know, a lot of urgent business in their lives last fall, and spent hours and hours and hours on this important task. I think it is an excellent report. I do not know of a single recommendation in it that we are going to tell the committee, that we disagree completely with and we're not going to do. There is a number, undoubtedly, as we study it, where we may take a different thrust to get the same objective.

The committee is no longer legally in being, however, we have had our excellent NASA Advisory Council, which is another external body, following, on a meeting-by-meeting basis, how we are doing. And we went through this status with them just yesterday. And we have been doing that periodically.

I hope to, and have invited the committee to return informally to us in some setting that would be agreeable to Norm, where sometime this summer we can go through the details, recommenda-

tion by recommendation. And the purpose of that would not be, frankly, to argue or debate any recommendation, but to make sure that the thrust of the direction that we are going will make NASA a more excellent Government agency in a very important national priority corner of our national business—to make sure that our thrust is the thrust that they intended. Or if it is not, so that they will understand it.

But, Mr. Chairman, thank you very much again for the opportunity to appear here with a man I admire very much and who represents a committee that did this country a great service.

[The prepared statement of Admiral Truly follows:]

PREPARED STATEMENT OF ADM. RICHARD H. TRULY

I am pleased to appear before the Subcommittee and to have the privilege of presenting the President's FY 1992 budget request for the National Aeronautics and Space Administration.

As we discuss the President's FY 1992 budget proposal for NASA, it is appropriate to remember the words of Dwight D. Eisenhower to NASA's men and women at the dedication of the Marshall Space Flight Center: "All that we have already accomplished, and all in the future that we shall achieve * * * is the product of unrestrained human talent and energy restlessly probing for the betterment of humanity * * * We are propelled in these efforts by ingenuity and industry—by courage to overcome disappointment and failure—by free-ranging imagination—by insistence upon excellence * * * hard work, toughness of spirit, and self-reliant enterprise are not mere catchwords of an era dead and gone. They remain the imperatives of the fulfillment of America's dream."

FY 1992 BUDGET

Today, those imperatives and that dream continue and are reflected in the President's budget request of $15.7 billion for NASA. This request manifests the President's belief that NASA activities make significant contributions to our competitive posture in the global marketplace, to our national pride and accomplishment, to our creative and intellectual spirit, to our understanding of the fragile Earth we inhabit, and to our economic and national security. An investment in NASA is an investment in America's future. I believe the American public also shares these views and supports our civil space and aeronautics program.

The FY 1992 budget request represents a prudent budget and a balancing of priorities in the Administration's overall budget submission. It's a sober assessment of the resources required to implement the civil space program approved by the Congress in FY 1991; it's a realistic assessment of the resources required to maintain U.S. leadership in space and to develop the critical technologies required for a secure economic and national future.

The President's budget request:

manifests the strong support of the President for the civil space and aeronautics program;

reflects Congressional guidance to temper the proposed rate of growth of the NASA budget and to restructure the Space Station Freedom; and

responds to the recommendations of the *Report of the Advisory Committee on the Future of the U.S. Space Program.*

It is a budget worthy of your support and a budget well within available domestic discretionary resources in FY 1992.

NASA IN 1990

As you are all well aware, NASA had its share of challenges in 1990. The Space Station EVA Report, the Hubble Space Telescope spherical aberration, and hydrogen leaks on the Space Shuttle all posed difficult engineering challenges and required serious technical reviews, top management attention and positive actions.

But 1990 also was a year of successes and accomplishments. In 1990, we launched six *safe* and *successful* Space Shuttles, we successfully guided the Galileo spacecraft past Earth on its way to Jupiter, we deployed the Hubble Space Telescope, the Ulysses spacecraft for the European Space Agency, two DOD spacecraft, and the Astro mission that, in addition to providing significant scientific information on black holes, quasars and other scientific phenomena, provided a unique educational forum for schoolchildren. We made progress mapping the surface of Venus as a result of

the Magellan mission, and we produced unprecedented images of the Milky Way, thanks to Cosmic Background Explorer, and of our solar system, thanks to Voyager.

REPORT OF ADVISORY COMMITTEE ON THE FUTURE OF THE U.S. SPACE PROGRAM

As effective as NASA has been over the years, it was clear to me that NASA needed to improve further to fulfill our future missions and promise. Therefore, I requested that an assessment of NASA and its future agenda be undertaken by an independent panel of experts. The results of this constructive assessment of NASA are contained in the *Report of the Advisory Committee on the Future of the U.S. Space Program* that was chaired by Norman R. Augustine. This report was thorough, left no stone unturned, and made recommendations that will help NASA to better implement our objectives and better manage the taxpayers' money.

Change is never easy. But it is clear to me that NASA must change if we are to successfully accomplish our programs and maintain and broaden our base of support. However, to implement this report will require more than the support of the NASA management, it also will require the support of the Administration, the Congress, as well as stable and adequate funding.

FY 92 BUDGET—MORE THAN DOLLARS

NASA's FY 1992 budget request is more than a request for dollars for programs and projects. It is a request for the assistance of this Committee to help make NASA a "more excellent" agency.

The FY 1992 budget request also represents the desire of the President to forge a *consensus* on the goals and objectives of the civil space program and to commit to provide the necessary financial resources, personnel, and facilities to implement the civil space program.

NASA'S MISSION—SCIENCE, TECHNOLOGY, EXPLORATION

What are NASA missions? Why should you support this budget request?

NASA's mission embodies three major areas of endeavor: science, technology, and exploration. Each of these missions is important to the overall goals and objectives of the Agency but, more importantly, each of these missions is important to national objectives that have been identified by the President and the Congress.

Today, I would like to briefly describe the key elements of each of these mission areas and to give you a better idea of what the NASA of the 1990's is all about. After I do that, I will briefly discuss the enabling investments contained in the budget request. These investments in hardware, research, spacecraft, launch systems, facilities, and people will turn our missions into realities. Finally, I will discuss the restructured Space Station Freedom plan with you and tell you about the special emphasis NASA is putting on education.

SCIENCE

In the 1990's, the NASA space science program represents a commitment to expansion of our knowledge of the universe we live in and the planet we inhabit. In FY 1992, we will continue to implement the Office of Space Science and Applications Strategic Plan, as recommended by the Augustine Committee and other NASA advisory bodies.

Planned Missions

Over the next five years, 35 major space science missions are scheduled to be launched and more missions are in the pipeline. Before the end of the decade, we will have visited Venus, Jupiter, Mars, Saturn, and the Comet Tempel 2, and we will have deployed three great observatories—the Hubble Space Telescope, the Gamma Ray Observatory and the Advanced X-Ray Astrophysics Facility. We also will have serviced these great observatories starting with the Hubble Space Telescope in 1993.

The 1992 budget request also supports a full complement of space science and applications payloads, including the Upper Atmospheric Research Satellite, ATLAS, the Advanced Communications Satellite System, the United States Microgravity Laboratory, the International Microgravity Laboratory, Space Life Sciences Laboratory, and Spacelab J. The FY 1992 budget represents a firm commitment to a solid foundation of ongoing programs and to the maintenance of U.S. leadership in space.

New Initiative—Lifesat

The proposed budget also includes funding for a new initiative to develop a recoverable life sciences satellite called Lifesat. This satellite will help define radiation protection requirements for the long-term habitation and exploration of space.

Mission to Planet Earth

FY 1992 also manifests NASA's sustained commitment to understanding the planet Earth. The Mission to Planet Earth (MTPE), NASA's contribution to the U.S. Global Change Research Program, is strongly endorsed in the budget submission and manifests the commitment of the Agency and the Administration to this program with important ecological benefits.

NASA is exploring ways to restructure MTPE as a continually evolving program and to investigate the use of different size spacecraft. Two weeks ago, an Earth Observing System Engineering Review Advisory Committee was established to assess alternatives for the implementation of the Earth Observing System program, including size of platforms, instrument configuration, and launch requirements and sequencing. Dr. Ed Frieman of Scripps Oceanographic Institute will chair this review, which will get underway in May and be completed by September 30, 1991.

The Earth Probes program also has a strong endorsement in this year's budget. These highly-focused Earth science investigations require unique orbits and sensors, and will give us the capability to collect data in the near-term on global ozone, ocean surfaces, and tropical rainfall. Five Earth Probe missions are currently planned and procurement activities were completed last week for the acquisition of data by the Ocean Color Mission from a commercial service (Hughes and Orbital Sciences).

TECHNOLOGY

Investment in technology is critical to maintaining U.S. competitiveness, enhancing our economic well being and assuring U.S. world leadership in space, and is a key element of the civil space program endorsed by the Augustine Committee.

Space Technology

Unfortunately, the space technology budget has fared poorly in recent years and NASA has been unable to make the investments in technologies that will be required to support many future space science, Space Station, and space transportation activities, or to invest adequately in technologies that will enable expanded human and robotic exploration of the solar system. The FY 1992 budget request enhances funding of this program area, and NASA has initiated a process to develop an Agencywide space technology plan by late 1991, to include review by an outside panel of experts.

Aeronautics

Meanwhile, NASA continues to move out aggressively with an aeronautics technology program critical to the well being of the U.S. in terms of trade, transportation, and national security. In the 1992 budget submission, emphasis continues to be placed on numerical simulation techniques to aid in more efficient aircraft and propulsion systems design, advanced composite materials and structures, and aircraft safety. In FY 1992, the High-Speed Research Program will continue to address the critical environmental issues associated with high-speed civil transport development by U.S. industry, and will initiate a critical enabling engine materials program.

High Performance Computing and Communications Program (HPCCP)

A new governmentwide HPCCP is also included in the budget request. The goal of the HPCCP is to improve computing capability by about 1,000 times over current systems by 1996. NASA plays a key role in this initiative and is responsible for bringing together interdisciplinary teams to accelerate the development and application of high performance computing technology to meet its science and engineering requirements.

National Aero-Space Plane

Joint technology activities between NASA and the Department of Defense on the National Aero-Space Plane (NASP) program continue to make great strides, and the FY 1992 budget request will support a 1993 decision on the development of two experimental flight vehicles. Investments in NASP and enabling technologies are vital to future generations of military and civil aircraft and to U.S. dominance of these critical markets.

EXPLORATION

Mankind has always had a fundamental need to explore and to expand his horizons, and the President remains firmly committed to the Space Exploration Initiative and his long-term goal announced in 1989 of manned and unmanned exploration of the solar system.

Early next month, Lt. General Thomas Stafford and his Synthesis Group will report on their work, and NASA and the Congress will receive their recommendation on enabling technologies and candidate architectures required to enable the exploration of the Moon and Mars.

For 1992, the budget is based on a strategy of supporting activities focused on conceptual mission studies and on selected, key long-lead technologies that will be necessary for any future exploration endeavors. These technologies are: space surface nuclear power, space nuclear and advanced cryogenic propulsion, and life sciences and life support technologies.

Meanwhile, I have initiated a search for a new Associate Administrator for Exploration and plan to have this new Associate Administrator on board in June.

ENABLING INVESTMENTS

The unique capabilities of NASA's Space Shuttle, Space Station Freedom, Expendable Launch Vehicles, the Advanced Solid Rocket Motor, the Tracking and Data Relay Satellite System, facilities and workforce constitute a critical base upon which we can achieve our missions. In the FY 1992 budget request, an additional element of this space infrastructure will be initiated as a joint program with the DOD—a New Launch System.

Space Shuttle and Assured Shuttle Availability Program

The Space Shuttle remains vital to our space objectives, and continues to demonstrate its unique capabilities to launch and retrieve payloads and to perform space research. The FY 1992 budget request represents a continued commitment to safe and reliable flight operations, including a new Assured Shuttle Availability Program that establishes a formal funding mechanism and process for high priority improvements in the Space Shuttle. The FY 1992 budget request supports 9 flights in FY 1992, 9 flights in FY 1993, and 10 flights each in FY 1994 through FY 1996, which is a very supportable transportation plan for the upcoming years.

Advanced Solid Rocket Motor (ASRM)

The FY 1992 budget request supports the ASRM program that will enhance Space Shuttle safety margins and reliability. We expect a significant increase in the performance capability of the ASRM-equipped Shuttle and plan to use the ASRM for the Space Shuttle flights to deploy Space Station Freedom when the ASRM is available.

Pursuant to Congressional guidance, NASA has initiated a group of studies relative to ASRM cost, performance, schedule, and safety enhancements. NASA also has submitted a "finding" to the Congress concerning its technical review of the ASRM nozzle and its decision to use an ablative material instead of a carbon/carbon material for the throat entrance in order to minimize technical risks and costs.

Production of Orbiter Hardware

Production of orbiter hardware in support of the current fleet's operational requirements will continue. This budget request also continues the procurement of structural spares to significantly reduce the time to repair a damaged orbiter and to maintain orbiter production capability. Work is continuing on the hardware necessary to provide an extended duration orbiter capability to allow an orbiter to remain on orbit up to 16 days, beginning with a planned 13-day mission for US-1 in 1992. And the latest addition to the Space Shuttle fleet, Endeavour, will roll out of the Rockwell Palmdale, California, facility next week, before being ferried to the Kennedy Space Center to be prepared for its maiden flight in May of 1992.

Expendable Launch Vehicles (ELV's)

In addition to the Space Shuttle, launch services continue to be procured from the private sector, where available, as part of NASA's continued commitment to a healthy and expansive commercial space industry and to a mixed fleet. The FY 1992 budget request accommodates the launch of the Tracking and Data Relay Satellite (TDRS) 7 on an ELV and NASA has requested funds for several missions for a variety of small, medium, intermediate and large ELV's.

New Launch System

The current mixed fleet of ELV's and Space Shuttles provides a base for our current requirements of transporting people and payloads to low Earth orbit. The Space Shuttle is the most versatile and advanced launch system in the world. However, the nation simply must have a more robust space transportation system in future decades. Therefore, the Agency has included funding in the FY 1992 budget request to continue technology development for a New Launch System for a range of payloads up to and including a "heavy-lift" capability. Options for configuration, cost,

capability, and schedule for such a launch system have been assessed by a joint NASA/DOD team. We are now in the process of presenting these findings and recommendations to the Vice President and hope to have approval for our concept and the associated budget requirements very soon.

This new launch system will be jointly funded and managed by DOD and NASA and will provide a range of cargo capabilities, incorporate an evolutionary approach to introduce new technologies, include a man ratable option and achieve significant improvements in operations costs and operational resilience.

Ground and Space Communications

The NASA ground and space communications networks provide vital capabilities to meet the requirements of all NASA flight projects: This is accomplished through the use of a network of NASA ground stations and by three Tracking and Data Relay Satellite (TDRS) spacecraft working with a highly specialized ground station. This budget request funds the equipping of a second TDRS ground terminal, TDRS spacecraft (TDRS 6 & 7), and development of an advanced TDRS to extend network service into the 21st century. TDRS 8 funds have been deleted from the FY 1992 budget request. As noted above, TDRS 7 will be launched on a competitively procured commercial ELV.

People and Facilities

NASA's unique technical expertise and facilities are the underpinning for the successful accomplishment of the nation's aeronautics and space programs. We cannot be leaders in space exploration without a first-class institutional capability.

The FY 1992 budget request represents a commitment to a NASA with the superior managerial and technical capability needed to monitor and direct civil space and aeronautics efforts. As the Augustine Committee appropriately noted, "NASA, and only NASA, realistically possesses the essential critical mass of knowledge and expertise upon which the nation's civil space program can be sustained." These world-class scientists, engineers, technicians, and support staff require your support and the resources required to do their jobs. Funding for additional civil servants is requested in FY 1992 primarily to meet the increased workload associated with the Earth Observing System. Additional contractor conversions are planned in FY 1992 to ensure critical in-house capabilities—these conversions are budget neutral.

NASA has also initiated discussions with the Office of Personnel Management to explore opportunities to designate NASA as a pathfinding agency for flexible personnel management. I have also announced the new position of Associate Administrator for Human Resources to ensure that NASA will be able to recruit and retain the best technical and managerial talent—the type of people required to carry out an ambitious civil space program.

In addition to first-class people, first-class facilities also are required to maintain our nation's leadership position. NASA's research laboratories, computing capabilities, aeronautical facilities, Space Shuttle launch facilities, rocket test stands, and deep space tracking stations are unique resources and key to maintaining our nation's leadership position. The maintenance, repair, rehabilitation, and modernization of NASA's facilities are required to protect the nation's investment and are high priorities in the FY 1992 budget request.

As a result of the review of the Advisory Committee on the Future of the U.S. Space Program and other internal NASA reviews, the NASA senior management is involved in a complex reassessment of the agency's management structure in order to ensure a better and more capable NASA. This review includes activities both at NASA Headquarters and at the NASA centers. To ensure a NASA capable of fulfilling its diverse and challenging missions, it is important that the senior management team have the maximum degree of flexibility to implement any necessary changes. As was noted in the Augustine Report, "the internal management structure of NASA is best determined by those having the ultimate responsibility for the agency's performance." As the Subcommittee assesses the FY 1992 budget request for the agency, it is important to remember that management flexibility and people resources are as important to the successful implementation of NASA's mission as are program dollars.

Commercial Space

In addition to NASA's direct investment in enabling technologies, space infrastructure, people, and facilities, the FY 1992 budget request continues NASA's commitment to work with the private sector to develop space hardware and transportation systems. A key ingredient to this initiative is the NASA Centers for the Commercial Development of Space (CCDS) program. Sixteen CCDS's, supported by NASA, combine the talent of the nation's university, industrial, and research communities to help create new markets for space products and services.

This request also manifests NASA's strong support and commitment to the utilization of commercially provided hardware and services, such as the Commercial Middeck Augmentation Module and the Commercial Experiment Transporter, and to the dissemination of technical information to the nation's business, research and industrial communities to enhance their competitive posture.

SPACE STATION FREEDOM

The cornerstone of the space program of the 1990's and the 21st century is the Space Station Freedom—the largest joint international endeavor in science and technology ever undertaken. Pursuant to direction in the Conference Report accompanying the FY 1991 VA-HUD-Independent Agencies appropriations bill, NASA submitted its plan for a restructured Space Station Freedom program to the Committee on March 20, 1991. This plan meets Congressional programmatic and budgetary guidelines, incorporates the recommendations of the Augustine Committee, honors our international commitments, is consistent with national space policy, and has been strongly endorsed by the members of the National Space Council, especially the President and Vice President who are committed to development of Space Station Freedom by the end of this decade to further American leadership in exploring space. I hope that the Subcommittee will agree it is affordable; simplifies assembly and operation; and reduces the size, complexity, number of Space Shuttle launches and extravehicular activity requirements, still meeting its priority user requirements—life sciences and microgravity research and maintaining overall safety. We need to forge a consensus on Space Station Freedom now and to redirect ourselves to implementation of the program. The NASA team has worked tirelessly in this restructuring exercise to meet Congressional direction, and I hope you will work with us to turn this program into a reality now.

EDUCATION A SPECIAL EMPHASIS

The FY 1992 NASA budget requests a 17 percent increase for Academic Programs and represents a sustained commitment on the part of NASA and the President to stimulate young people's interest in science, mathematics, and engineering; to provide resources and training to enable teachers to incorporate aerospace concepts into their classroom lesson plans; and to support our nation's universities and graduate students in mathematics, science, and engineering. NASA has readily adopted the national educational goals set by President Bush and the nation's Governors and has formulated a Memorandum of Understanding with the Department of Energy to collaborate on education programs to help improve the nation's science, engineering, and math programs. NASA is part of a multiagency Education and Human Resources initiative coordinated under the auspices of OSTP's Federal Coordinating Council on Science, Engineering and Technology (FCCSET).

The FY 1992 budget request continues important ongoing programs such as the Spacemobiles, LASER and Space Grant Colleges and Fellowship Program, plus new educational initiatives geared to minorities and women. Experimental programs are aimed at regions of the nation that have not previously benefited from research activities in space science and engineering.

NASA's investment in educational activities is a critical element of a comprehensive civil space program and a sound investment in the scientists, engineers and astronauts of tomorrow.

SUMMARY

"Some say the space program should wait—that we should 1only go forward once the social problems of today are completely solved. But history proves that attitude is self-defeating. Many an American school kid has read the story of Columbus' doubters, and shook their heads in disbelief that these naysayers could have been so shortsighted. We must not let the schoolchildren of the future shake their heads at our behavior."

Mr. Chairman, I believe these remarks last year by President Bush to the men and women of NASA are appropriate for all of us today. We are standing at the edge of a new frontier and the rewards are enormous—from better understanding of our universe and our planet, to new materials, medicines and medical under standing, from new technologies to new products and processes that will capture future markets. But unless we are able to forge the necessary consensus and make the necessary commitment this year, this chapter of the American dream will be written by future generations—not by ours. The FY 1992 NASA budget request represents the blueprint for the civil space program for which we seek your commitment.

Mr. Chairman, let's put the consensus in place this year, let's agree to provide the resources, and let's start this incredible voyage into what the President has called "the next American century." History proves that we have never lost by pressing the limits of our frontiers. Together, let's write another chapter of American history.

FY 1992 NASA BUDGET REQUEST

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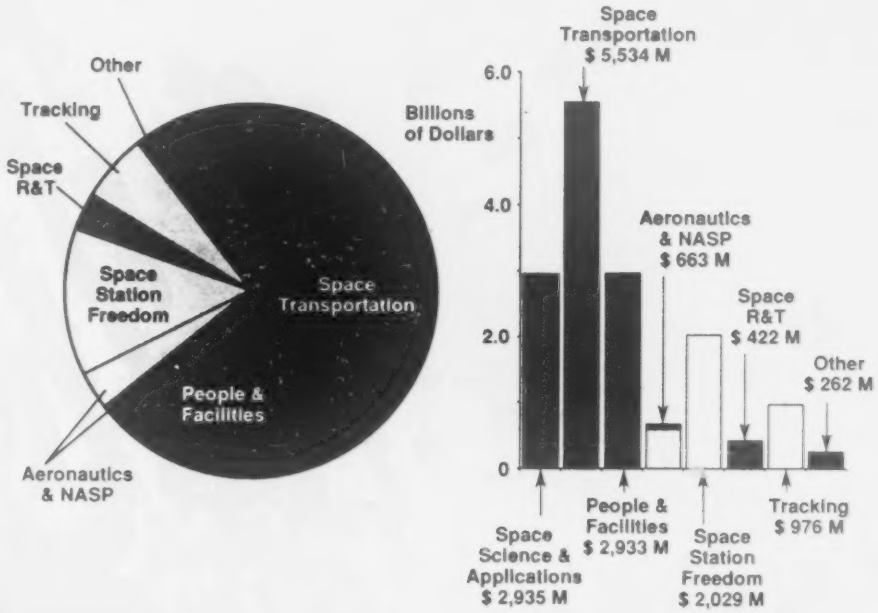

Senator GORE. Thank you, Admiral, and thank you both.

Let me ask about some of the advisory committee's specific recommendations. In examining the space station, your committee, Mr. Augustine strongly recommended the introduction of a one-way crew return vehicle, correct?

Mr. AUGUSTINE. That is correct.

Senator GORE. You believe that that should be added as part of the space station program, and the members of your committee agreed with that.

You agree with that too, do you not, Admiral Truly?

Admiral TRULY. I certainly do.

Senator GORE. But yet you agree with it. And officially NASA concurs with it. But that has not happened yet. Why not?

Admiral TRULY. It is a budget issue, and we discussed it briefly or not briefly at the previous hearing. The proposed space station program does have a requirement in it for an assured crew return vehicle—ACRV.

However, the difficulty that we are in on that program is that since that vehicle is not required until permanently manned capability, which is the turn of the century, we simply have not done an adequate phase A and phase B definition study, and since we wanted to be an economical, cheap, if you will, lifeboat for the crew.

And as we do not know, within several hundreds of millions of dollars, the cost of it, we were unable to define it precisely and therefore get a new start authority through the OMB to make that.

However, under the guidelines of the Congress that were given to us, and in discussions with the committees as we went along, we have identified that to the Congress, so that you would be fully aware of our intent along that line.

It just does not have the maturity of the basic space station design.

Senator GORE. Well, with all due respect, OMB has not yet agreed to that recommendation of the Augustine Committee. Is that a fair statement?

Admiral TRULY. No. The process that we went through first of all was that NASA defined the reconstructed space station program and included in it the intention to go for assured crew return vehicle as a new start in 1993 or 1994.

I conducted internally to NASA an independent cost review of that entire program. I then submitted it to the OMB and we went through that with OMB. They did an independent cost review, and we did identify the requirement for that to be a new start, but since it was not a fiscal year 1992 start, nor had we done the phase A, they put it into their out-year budget planning numbers, and have accepted the requirement.

Senator GORE. But, and again, I do not want to cover ground that we plowed pretty thoroughly earlier this week, but I want to place these questions in the context of the Augustine Committee recommendations because what the Augustine Committee is telling us, as I understand it, is we need to set some clear priorities.

Space science needs to be first, and other projects need to be evaluated with an eye to what the full funding of those programs might mean for the higher priorities.

If NASA presents the space station program in a way which serves effectively to exclude more than 2 billion dollars' worth of costs, then our ability to follow through on the recommendations of the Augustine Committee and yours may be thereby hampered.

You submitted to us, not only the fiscal year 1992 budget but your best calculations of what the budget in fiscal year 1993 and fiscal year 1994 would be, and in trying to squeeze space station and all of the other priorities which you have outlined for us into a limited amount of dollars, we are being asked to evaluate the space station proposal according to numbers which do not seem to be accurate.

Now it is quite true, you are openly telling us, you would like to see this included as part of the program. If we do include it as part of the program and if we do include the other items which you believe are essential for the program, then we have to calculate another $2 to $3 billion as the cost of that program.

And in doing so, we have to consider the implications for the priorities which the Augustine Committee has said are higher. Now I do not like where that line of logic leads, but we are going to have to get a full and clear view of exactly what these decisions imply in the fiscal year 1992 budget, and resist the temptation to pretend that it is going to cost less than it is, because if we do that, then we cannot follow the Augustine Committee recommendations.

Do you want to comment on this, Mr. Augustine? Let me put that another way. I am sure you do not want to comment on this, but will you comment on this? [Laughter.]

Mr. AUGUSTINE. I would be happy to comment, Mr. Chairman.

Our committee really addressed the requirement, the technical aspect of a crew rescue system, and it was our belief that it was important to have such a capability.

We felt that it was needed at the time that the space station became permanently tended, which occurs, if my memory is right, somewhere around 1999.

And so it is not an activity that is urgent in a time sense, but we viewed it as being urgent in a requirements sense. We did not, candidly, examine how it should be budgeted.

Senator GORE. But you did say that in evaluating the overall space station proposal, it should be put on a go-as-you-pay basis; correct?

Mr. AUGUSTINE. That is true.

Senator GORE. Now in deciding whether and when to proceed on a go-as-you-pay basis, we have to have a clear view of what the pay side of that equation is in order to evaluate the go side of the equation.

I do not want to beat a dead horse on that, but in the material that NASA has provided for us here, that particular recommendation is marked down as NASA concurs, and you marked down the intent to extend phase A contracts in April of calendar year 1991 for the one-way crew return vehicle.

Now after a cursory review of NASA's presentation to the committee of how you are responding to that recommendation of the Augustine Committee, I would look at this and say well, NASA concurs with this, and as of April 1991, it is proceeding with contracts to implement this recommendation.

But then I would look at the budget submission, and I would wonder, well, why is it not in here? Then I would look at the Augustine Committee recommendations and say, well, look at the budget and then decide when to go. Look at the budget, it is not there. It is here, but it is not in the budget.

You understand the problem you present to us?

Admiral TRULY. I understand. If I might comment. First of all, let me comment in two ways. First of all, on the basic recommendation itself, to have a crew return vehicle: We absolutely agree and it is a very simple logic, and that is, if human beings are going to be put aboard a space station permanently while the shuttle is not there, they deserve to have a way to come home that is assured.

And that results in a lifeboat, a small vehicle that is not yet designed, and we hope, comes in well below $2 billion, and that is the reason that what we call a phase A, which is a preliminary scoping of a technical project and then phase B which selects specific configurations, properly accomplished prior to going into a development and production phase.

And the contract that you referred to that is in my report to you this morning is a small contract that is a part of that phase A procedure, and we frankly, need to do the phase A and phase B before initiating a new start, so that we understand the costs presented to the Congress.

Senator GORE. But, Admiral, if I could interject at that point. One of the problems which led to the creation of the Augustine Committee was the tendency on the part of NASA to come to Congress with the narrow end of a wedge and have several wedges all with narrow ends in the same budget, and then 1, 2, 3, several years down the road, as all of those wedges reach wider proportions. They squeeze the total amount out of the bounds of what is available. Then all of the programs are then spread so thinly that there are problems in all of them.

And so, well, you know exactly what I am saying here. I think we have probably covered this, but if you want to comment further——

Admiral TRULY. Well, I just wanted to say, that is the very reason to do a professionally done phase A and phase B, so that you have a program that is properly scoped and with the direction last year from our Appropriations Committees, as to the development funds that were to be available, we have identified that general outline of that that is within those development funds, not the operations funds, but the development funds, across a program that has a—even though the reserves are tight in the front end, are quite adequate to the end of the century, and have identified that to the Congress.

Senator GORE. But, Admiral, with all due respect, doing it this way is quite sound as a management approach, no question about it. One reason to do it, as you say, is to get a clear idea of exactly how much it will cost.

But as I understand what you are saying and what Norm Augustine is saying, there is no serious disagreement now about the fact that it should be a part of the space station program, at least no disagreement among the two of you.

And this phase A contract should not therefore be considered as an effort to decide whether or not it is part of the program or not. It is part of the program; is it not?

Admiral TRULY. That is right. It is to define it.

Senator GORE. OK. But, the budget submission assumes for us that the cost is not uncertain. It assumes that the cost is zero.

Admiral TRULY. That is not my interpretation of what we have submitted. We were given an out-year outline in the appropriation bill as to a level we should plan to grow to, and then level off at for the development portion of the program.

There is room in that outline for the knowledge that we have today for the ACRV Program, and we have provided that preliminary information to the Congress, but we do not know within $500 million as to what the program can cost, and for the 1992 budget, we have identified what we need.

We certainly have not made—as a matter of fact, we have done the opposite, we wanted to make sure that the Congress was well aware of where we were in this development, both technical and budgetary, so you could make your judgments.

Senator GORE. I will conclude on this and defer to my colleagues for this round. But I would like to close this round by simply saying that what you tell us informally is appreciated, and serves to discharge your responsibility for candor, and we acknowledge that and appreciate it.

But what you formally present in the budget submission and what we formally pass on to the full committee and then to the full Senate has legal meaning, and has implications for what options we can exercise over the next several years.

By costing this essential part of the space station at zero in the formal budget figures that we use in playing out this legal exercise, you encourage us to award a result which will inevitably involve a sudden expansion of the costs projected for space station, at a time when there will not be more money to pay that.

And the implication for us will be, well, let us look at these other things in the NASA budget and start cutting them out. Some of the ones that would be most vulnerable will be items that the Augustine Committee has told us are a higher priority.

We will come back in my next round. I apologize to my colleagues for taking more time than I had thought I would.

Senator Pressler.

Senator PRESSLER. Mr. Augustine, at this week's hearing on the space station, the Space Studies Board suggested that the most credible justification for the space station is that it is a step on our way to Mars.

Is it fair to say that if the advisory committee had to prioritize NASA's programs, it would place its space science research program above building the space station? Do you agree that one of the space station's most important benefits will be its contribution to Mission from Planet Earth?

I guess what I am getting at here is what your priority would be.

Mr. AUGUSTINE. Yes, Senator Pressler. It is a complicated question, because the space station supports one form of science—at least one form; namely, life science. But it is true that the general science program, and I use it in the broadest sense, the term "science," would in our mind have higher priority than essentially any other part of the NASA budget.

Having said that, we certainly would not suggest that that is the only thing NASA should be doing. Obviously, it is a question of balance, and you asked whether we viewed the space station as essentially tied to the Mission from Planet Earth, and yes, we would view that as the next key step in having a manned space program for America.

Senator PRESSLER. Now, your report emphasized the importance of adequate funding for the Earth Observing System's data management activities in order to ensure that data collected is accessible. Are the current funding levels adequate to ensure accessibility, and how should the Earth Observing System data be managed?

Mr. AUGUSTINE. Senator, our committee did not investigate the adequacy of the funds to a degree that I would feel competent to really give you an opinion.

I think I could say that it has been characteristic of major data-gathering programs in the past, not only within NASA but throughout the private sector and in Government as a whole, to underestimate the magnitude of the task of storing, processing, disseminating, and analyzing data, and the EOS will be a prodigious generator of data, and so a good deal of thought obviously needs

to be given to how we are going to capture that data and use it effectively.

As to the adequacy of the budget that is now shown for that, I am afraid I am not qualified to answer.

Senator PRESSLER. Could we submit some written questions to you that you, after you take a look at it——

Mr. AUGUSTINE. I would be very happy to do that.

Senator PRESSLER. I would like to—I have been concerned that between 40 and 50 percent of the data obtained is not archived in some cases, and is just not available, and when we have these missions I think it is very important that we properly utilize this.

Senator GORE. Would my colleague yield on that point?

Senator PRESSLER. Yes.

Senator GORE. We are going to have a separate hearing in May specifically on the EOS information system, and we will be looking, of course, at Sioux Falls, naturally, but also the rest of the whole information system. We think it is such a priority we are going to really focus on that.

Senator PRESSLER. Good. Thank you very much, Mr. Chairman.

Let me ask a question that has been—that I have tried to do some work on over the years. That is, one of the concerns in your report is matter of salaries and compensation.

I know there are Government pay scales and there are private pay scales, and there are times when we have been told that it is hard to keep people in certain Government jobs at a Government pay scale, although I tend to believe that if they have a clear objective, a lot of them like the excitement of Government service more. Nevertheless, people will eventually, if they have children in college, or whatever their financial needs are, go elsewhere.

Your report raised this question. What are your recommendations to reduce the discrepancy between salaries in the private sector and NASA?

Mr. AUGUSTINE. Well, Senator, I myself spent a decade as a public servant and I am very proud of it, and enjoyed those years. But I think it would be fair to say that our committee believes that the current Civil Service system is in general not consistent or compatible with attracting and keeping in large numbers the kind of talent it takes to carry out the missions NASA has.

Pay is just one of those factors, in our opinion, and I would certainly never want to argue that pay should be a reason for being a public servant, but I would argue that pay should never be a reason to not be a public servant, and I am afraid that we have moved in the latter direction. NASA has a lot of very talented people, obviously, and our concern really addresses their ability to keep those kinds of people.

The pay scales, as we judge them within NASA, are just not competitive with what the private sector pays for a given skill and a given talent level, and the disparity in that pay scale gets even more damaging as you move higher up in the organization to the more senior, more experienced people, and as you say, when people approach having children and college, no matter how much they love their job, sometimes they have to face reality, and so we were very concerned.

It needs to be recognized that NASA's skills are fairly unique, and if we are to have the kind of talent we need, we need to pay competitive scales, we need to have pay adequately for people to move from one location to another. We have got to be able to hire people quickly, we have got to be able to fire people who do not perform, and all of those things in my experience are much, much more difficult in the Government system, not just NASA, than they are in the private sector.

Senator PRESSLER. Now, Mr. Augustine, NASA has always been charged with transferring space-derived technologies to the private sector. We always hear a lot about privatization. Now, it is true that, for example, the communications satellite industry has evolved from the technology transfer that started with the first weather satellite.

Your advisory commission recommended that NASA encourage the fullest commercialization of space, and surely everybody I suppose agrees with that in principle, but what did you really envisage? What should NASA do to encourage commercialization of space? Why is it that commercialization has not worked in the LANDSAT Program? Are we really talking about something realistic here?

I guess that is the question.

Mr. AUGUSTINE. Senator, that is a very tough question, but an important one.

I think it would be argued that in recent years—and probably not a decade or two ago, but in recent years NASA has tried very hard to assist privatization and commercialization. There have been successes. The greatest one you allude to, which is the communications satellite industry.

There have been lesser gains. We have an embryonic launch vehicle industry in this country that I am not at all sanguine about its future, candidly, through no fault of NASA's but through problems of international competition.

We have a great deal of effort underway in more specialized areas, including space processing of materials, medicines and things like that.

I think it is the view of our committee that many of these opportunities may have been oversold, in terms of developing major industrial capabilities or measure commercial capabilities.

The unfortunate fact is that space has a high threshold entry cost. The cost of doing things in space is simply so high that it makes it very difficult for companies to develop, or to generate an ROI that makes sense to undertake these projects, and I think that has been the greatest impediment.

You asked, what should NASA be doing to help? I believe the old NACA model for the NACA really, at least in my opinion, was a foundation of America's commercial aircraft manufacturing capability. It was a wonderful success story, and what NASA is doing in the space area I think should closely parallel what it actually did in the NACA.

Senator PRESSLER. I guess in this whole business we have to talk budget. That is what this hearing is about. But—and I am sort of rephrasing a question the chairman asked. Now, the advisory committee's recommendations are based on, as I understand it, yearly

10-percent real dollar increases in the NASA budget for all the 1990's; is that correct?

Mr. AUGUSTINE. Yes. We said approximately.

Senator PRESSLER. OK. Now, the budget agreement severely limits its discretionary spending, so NASA's budget may not be able to grow at that rate, as I understand it. At our hearing this week on the space station we heard that any reduction in the growth of NASA's budget could kill the station, if NASA's budget does not grow at 10 percent in real dollars. How would your report's recommendations on the space station, Mission to Planet Earth, and other programs, be affected?

Mr. AUGUSTINE. We did a top-down budget analysis, not a detailed line-item analysis. It was our conclusion that the money being spent for the space program, which is today about one-fourth of 1 percent of the GNP, as compared with about eight-tenths of 1 percent at the peak of the Apollo Program, is an amount that seemed to be to us within the realm of the affordable.

We obviously are not aware of the other tradeoffs that your committee has to make, but it did seem to us that the space program has increased in real dollar value for a number of years each year. The President's budget that was submitted was quite consistent with what we had hoped to accomplish, and I candidly would not be able to argue one way or the other within 1 or 2 percent or so whether we were precisely right or not, but if we cannot be somewhere in the vicinity of 10-percent real growth, then clearly we cannot undertake the program we described.

That leads to what you said about, well, what are the priorities then, and we would argue strongly for preserving balance, but within that, we try to suggest some ways to deal with budget changes either up or down. If one faces a downward budget, as I said, the science program would deserve a high, but not the only priority, obviously.

We suggested deferring the additional shuttle orbiter, which in fact NASA has done. We suggested making no new major starts, with the exception of the launch vehicle—the unmanned launch vehicle—until this budget challenge begins to ease a bit. We suggested some management changes that might lead to modest costsavings. I would not look for enormous savings there. We suggested a redesign of the space station to save money, and so on.

So, those are the kinds of priorities that we would have cited.

Senator PRESSLER. One final question. I know that when these commissions come, frequently they recommend a streamlining from the point of view of public administration. I noted that your advisory committee recommended the establishment of an associate administrator for space flight operations, an associate administrator for human resources, an independent cost analysis group, and the creation of an executive committee for the Space Council.

Normally, when one thinks of reform, one thinks about eliminating layers of bureaucracy. Why did the advisory committee recommend creating these new positions?

Mr. AUGUSTINE. Well, some of the associate administrator positions we recommended were combinations of other positions or eliminated positions, but there was a net increase. Similarly, the executive committee for the Space Council would really be an orga-

nizational mechanism that would be a subset of the existing council, so really, if anything, I think would lead to streamlining.

But you are correct, that we did recommend the addition of two new headquarters functions. You named one in the cost area and one in the systems concepts and planning area, and those were investments that are small in terms of number of people and costs, but that we thought were needed and would have a very great payoff, because they impact very large downstream expenditures.

Senator PRESSLER. Thank you very much, Mr. Chairman. I will have some questions for the record on the costs of archiving, and so forth.

Senator GORE. Senator Bryan.

Senator BRYAN. Thank you, Mr. Chairman. Among the findings I note, some of which have been commented on this morning in the Augustine report, there is a finding that the Civil Space Program is overly dependent upon the space shuttle for access to space.

And I further note that in the budget submission, there are two new projects that are mentioned, one of which is a new launch system in which you have requested, Admiral Truly, $175 million for fiscal year 1992.

As you know, in the 1960's and into the 1950's, there was a program at the Nevada test site, at the NRDS, called Project Rover. It was a second-stage nuclear propulsion system in which probably more than $1 billion was spent on that project.

I ask the question in light of an article that appeared in Time magazine this week in which a booster rocket by the name of Timberwind, which would also be a nuclear-propelled rocket, is that part of that $175 million that you are talking about? Or are we talking about a totally different system?

Admiral TRULY. No, it is not. The $175 million request to the Congress in our 1992 budget is matched by a like amount in the DOD. And those moneys are to develop a new launch system that would be a combination of new technology, principally a new engine development. This country has not developed a new rocket engine in about 25 years. It would be a combination of new technology and the use of some existing hardware or modified hardware either out of the space shuttle program or existing expendable launch vehicles. And it was a direct result of the recommendation of the Augustine Committee that we move out on such a program. But there is no part of that program that is associated with nuclear propulsion at all.

Senator BRYAN. In this article it mentions NASA's involvement. It does not dispute what you are saying, but does mention NASA's involvement with this particular booster rocket named "Timberwind" and suggests that the agency would have an interest in that because it would provide an alternative to the present launch modes that are available.

Are you involved in that project at all, Admiral Truly?

Admiral TRULY. If I might, let me answer the question in two ways. First of all, I did read that article in Time and other articles around that program that they identified by the name Timberwind. I do not want to make any comments about any classified program that DOD is presently funding or developing. I really do not have any comment whatsoever on that program.

On the other hand, it is quite normal for us in NASA to look at architectures for future exploration program that would take the advantage or use the advantage of upper stage nuclear propulsion. And there are great advantages. But it is based on the assumption and the premise that if a new development was undertaken it would be a safe use of nuclear propulsion executed in such a way that it would not expose an undue danger to the launch or the low-Earth orbit regime, but would be used principally for interplanetary differences.

And I think that is a totally legitimate study that we can and do look at. But the $175 million request and the new launch system have nothing to do with nuclear propulsion whatsoever.

Senator BRYAN. That was my followup question. Putting aside the question of Timberwind and the activities that may be occurring with respect to that project, does any of the new launch strategies that you are considering involve nuclear propulsion, either in a first or secondary stage?

Admiral TRULY. No. As you know, in addition, if I might make one additional comment, in addition to the committee that Norm Augustine headed up, we have also put into place another group with another purpose headed up by Gen. Tom Stafford, which we call the Synthesis Group. That word simply came from the job that we gave them, to have a major outreach program and to synthesize all the inputs that they would get from NASA, from DOD, from academia, from universities and to suggest at least two significantly different architectures under which we would execute an exploration program.

The Stafford Committee, the Synthesis Group, has not issued its report. I believe within the next 30 days it will. I am very interested in what it will say both in a macrosense about architectures, but also about technical approaches to exploration. And one of which, would be normal for them to comment on, would be upper stage nuclear propulsion, not Earth to orbit, but——

Senator BRYAN. I understand.

Admiral TRULY. And so we are interested in getting that report. But we have not received it yet.

Senator BRYAN. Aside from that report and aside from Timberwind, is NASA involved in funding any other types of nuclear propulsion research, any projects?

Admiral TRULY. We have no developments underway. We are a part of an interagency group in the SP–100 nuclear power program that has been underway for some time.

Senator BRYAN. I am familiar with that one.

Senator GORE. If I may suggest, I notice that you have a number of your backup folks with you. If you need to check with any of them on that particular response, feel free to do so, on other nuclear propulsion research.

Admiral TRULY. I will.

Mr. CAMPBELL. We did request $7 million for nuclear propulsion.

Senator GORE. Please identify yourself for the reporter.

Admiral TRULY. This is Mr. Arnie Aldrich, who is Associate Administrator for Aeronautics, Exploration, and Technology.

Senator GORE. And repeat the information about the $7 million, please.

Mr. ALDRICH. Mr. Campbell, the Comptroller for NASA, quoted that we have $7 million for nuclear propulsion proposed in this budget. And I was going to also comment further on that $7 million.

Your question was, Are we funding today any nuclear propulsion programs within NASA? And the answer, as Admiral Truly has stated, "No." In the budget that we proposed for 1992 in the exploration area we have proposed several initiatives on the longest lead and the highest payoff new technologies that should be pursued for long-range manned exploration missions.

And one of those areas selected is the area of nuclear propulsion. And we propose with that $7 million to do studies in conjunction with the Department of Energy on what nuclear propulsion systems should be pursued and would be the kind that would have payoffs. The $7 million is for studies both in nuclear thermal propulsion and in nuclear electric propulsion, but not actually for entering into those programs until we understand better how to proceed.

Senator BRYAN. And I thank you very much.

If I might, Mr. Augustine, ask a question of you. You expressed concern, concern that I think is shared generally in the scientific community, about the erosion of NASA's technology base. Do you include in that concern the human resource, that is the seeming inability to attract young people into fields of science careers?

I know myself that when the Sputnik was launched in the fall of 1957, it really electrified the world and was a catalyst for a tremendous national consensus, even among those who did not and do not have the scientific bent, interest, or background. It seemed to me we were able to attract the best and brightest, if you will, of this country to go into the field.

My sense is that we are having a real problem in attracting the same level of interest and commitment from that same best and brightest of the current generation that is involved in going through our educational process. Would you comment on that, if you would please?

Mr. AUGUSTINE. I especially would like to comment on that because I think it is the heart of the space program. We can have the best plan and the best organizational structure and the most money and we still will not succeed if we do not have the best people.

As I said earlier, I think NASA today has some awfully talented people. But the situation has changed since the time you described when Sputnik was launched. I was in graduate school at that time. I remember it so clearly. And that was one of the things that propelled me to be interested in space.

I talk to a lot of students in my job. For example, last week I spoke to about 300 or 400 young people at MIT and had a chance to interact with some of them. They were all present because they were interested in space, more than interested, they were excited about it. Many of them said that that was the reason they were studying engineering, they were excited about space.

But there is the reality that when they go to work they want to be able to work in surroundings that are pleasant. They want to be able to have adequate research facilities. They need to be paid

a competitive salary. As I said, when they are moved as part of their job they need to recover the cost of their move.

And many of these things are, I think, in jeopardy, our committee, the Committee on the Future of the U.S. Space Programs, believes are in jeopardy because the civil service pay scale, as best as we were able to analyze it just is not competitive with what we pay in the private sector.

I avoid personalizing these things, but I will violate that for a moment and say that some of the most talented people in our company, including our President, are people who have spent some 20 years or so at NASA and elected to leave, not because they did not love the space program or like working at NASA, but they had kids in college and had to pay tuition. That is a tragedy for the country.

Senator BRYAN. I appreciate that comment. And if the chairman will indulge me for just one other brief line of questioning.

Admiral Truly, back to you, one of the observations by the Augustine Committee is that NASA is currently overcommitted relative to available resources. Would you agree with that finding?

Admiral TRULY. I think, and I have said this before publicly, I think NASA has in past years been more excited and more easily convinced that we should do exciting programs and therefore put them on our plate, than in past years we have been able to make the hard choices to cancel started programs and take them off our plate.

I believe that that has changed and is changing and is reflected in the 1992 budget. We did cancel a major program, the Orbital Maneuvering Vehicle last year simply on the basis of budget outlooks.

Frankly, it is always a difficult question in the space business because of a lot of factors as an administrator as to whether or not you are putting the future agency in jeopardy by new starts that assume, naturally, that funding will be available for.

And that is why I think it is so important that the Congress and we and the administration and NASA take heed of this particular report and strike a balance and come to consensus about the goals of the space program. Naturally, I would not be in the business, nor would Mr. Augustine, if space did not excite us and if we did not believe that it was a fundamental important investment in the country's future.

But J.R. Thompson who is here in the room, but not sitting at the table today, and I have tried very hard to propose to the Congress a prudent and well thought out budget which is represented, as a matter of fact, I think, in our space station proposal.

Senator BRYAN. You mentioned two things that I want to follow up with. You mentioned the need for a national consensus. Mr. Augustine made reference to that. I think that is correct. You talked about the budget priorities.

I would like to ask you in light of the national consensus, the budget priorities, the constraints that you have, one program that is included in the budget that I think is questionable in light of the fact that we have got a $370 billion deficit that is built into the current fiscal year and the public is clamoring for more responsibility on the part of Congress to do something to bring spending under control.

The program that I have reference to is the Search for Extraterrestrial Intelligence. I guess that is the search for, is there human life out there in the universe.

Now you have requested a $14.5 million appropriation for that as I understand the budget documents. As tested by the criteria of national consensus in terms of budget priorities, how do we justify to the American people the expenditure of $12 million to see if, indeed, there may indeed be some life out there on some other planet or some other solar system?

Admiral TRULY. Well, if I might comment briefly on the program. It is an advanced communications program that is doing new technologies and new ways to look at signals and to see if there are nonrandom signals in the noise that comes to the Earth from all directions, but particularly focused at the nearby stars. It is a scientific endeavor. And it is, frankly, unknown what the likelihood of detecting such a nonrandom signal in that noise.

Senator BRYAN. I understand that. I guess that is why I raise the question. But with budget constraints, is that really a priority for the agency?

Admiral TRULY. In our view the impact to those of us on Earth who inhabit today the only known planet around any star that is capable of supporting life, the impact of that knowledge, in our view, makes it worthy in the scientific priorities in view of the science budget which is about 23 or 24 percent of our total budget. That $12 million is a small science program that we believe is worth the investment.

It has been a debatable program. It is not a search for little green men. It is a search to understand if there are, in fact, nonrandom signals coming from any direction in the universe. In it, principally, the money is actually expended on advanced communication technologies and data analysis.

Senator BRYAN. My last question, Admiral, is the Super Guppy. What are we doing with the transport plane. Are we going to rehabilitate it or are we going to get rid of it? And I will yield back.

Admiral TRULY. The Super Guppy is sitting on the ramp at El Paso and we have not identified a need for it. We are looking to get to find someone else who could usefully use it.

Senator BRYAN. I would urge you to do so. As I recall, the Inspector General, back in 1989 said, rehab it or get rid of it, but just do not let it continue to bring——

Admiral TRULY. And we went through that and we decided to get rid of it. And it is sitting on the ramp. I read in the paper the other day that we were spending money storing it. We are not. It is not even using up hangar space we are renting.

Senator BRYAN. Thank you very much, Mr. Chairman.

Senator GORE. Thank you, Senator Bryan. Let me follow up on the questions that Senator Bryan began by asking, which were in the general area of new launch systems. Admiral Truly, I know that earlier this week, if fact, as we were starting our hearing, you were meeting with the Vice President and the Space Council on the new launch system.

Can you shed any light for us on the details of this proposal, such as, for example, its cost and its expected availability date?

Admiral TRULY. Yes, we did meet earlier this week. As you know, it was a meeting with the Vice President. Mr. Darman was present, Deputy Secretary Atwood from the Defense Department, and myself. We told the Vice President at that meeting about the work that DOD and NASA had done since the first of the year. We are together on a technical approach which is an approach that uses both the present-day hardware and new technology, principally, a new engine. It has the capability of meeting both DOD needs and NASA needs in logistic supply for a space station. And it is not required by anybody until—the earliest possible requirement date would be 1999, which, if it were available at that time, would be usable by us. The DOD does not it that early.

And we described this program to the Vice President, we told him that we were together both on the technical side of the program and on the management structure of the program. And he told us to go do a little bit more work on cost and schedule issues so that we could get back with him. But the general approach would be to fight hard for the funds, the $175 million that was mentioned before in both budgets; to get particularly started on the engine development; and then make a decision in late 1993 as to what precise schedule the vehicle should be on.

The earliest possible schedule would be for a 1999 first flight. The cost range of the vehicle will be in the neighborhood of $10 to $12 billion. But that is more than the launch vehicle. That is facilities, an upper stage required by the Air Force, and is called a "cargo transfer vehicle," which would be required by us to take payloads from orbit insertion to rendezvous dock and to space station.

Senator GORE. And the mission for this new launch vehicle?

Admiral TRULY. Perhaps I should defer to Norm on this, but the recommendation for the new launch system in the Augustine report on the NASA, on the civil space side of the ledger, was simple to be a—not an alternate, but a supplementary system to take usepressures off the Space Shuttle Program because we believe we are going to be flying the shuttle for a long time. And therefore, our use would be logistics supply of space station——

Senator GORE. After the space station is deployed.

Admiral TRULY. Yes, we did go though a detailed transportation study about space station assembly, and we had taken enough shuttle flights because of the downscaling of the station out of that, that we are convinced there is plenty of margin in the shuttle system through assembly. However, if we had a supplementary expendable launch vehicle that could do the logistics supply in the many years Space Station Freedom would be used, those would be shuttle flights saved.

Senator GORE. So, it would be an alternate way to service the space station?

Admiral TRULY. That is correct. And the program is evolvable to a heavy-lift launch vehicle by the use of advanced solid rocket motors in future years.

Senator GORE. And the DOD mission?

Admiral TRULY. I should let the DOD speak to theirs, but the DOD mission simply is looking forward into the next century. They believe that they have a number of military requirements that require sometime in that first decade of the next century, to replace

the current Titan IV system. But I should let the DOD speak to their requirements, and not me.

Senator GORE. Now, $10 to $12 billion between now and 1999. What portion of that—is it 50–50?

Admiral TRULY. Yes, the plan is that this program would be a 50–50 development of the core launch vehicle. The specific additional developments that are required, the upper stage for the Air Force for example, would be entirely DOD funded. The cargo transfer vehicle required for space station logistics would be entirely NASA funded. In general, it still turns out—and I do not have that data in front of me—it turns out that it is a true partnership throughout. But it is 50–50 funding for the launch vehicle itself.

Senator GORE. Now, Mr. Augustine, is this what the advisory committee had in mind, an $11 billion vehicle, when it made its recommendation?

Mr. AUGUSTINE. If I might answer that by saying a little bit about what it was we hoped to accomplish with the vehicle, and then I will try to specifically answer that. We were concerned about the resiliency of the shuttle as really the underpinning of the whole Civil Space Program. It seemed to us that we should not have a space program that is dependent upon no failures of the shuttle in the next decade during the time it takes to set the space station on orbit. And in fact, when one is dealing with statistics and all the vagaries of statistics, it seemed to us not unlikely we could lose a shuttle before the space station is on orbit. And the consequences of that, we were concerned, could be extremely disruptive, in addition to the obvious consequences and loss of life and loss of a major part of our space launch vehicle inventory.

It was really that consideration that drove us to wanting a new launch vehicle. Given that one were to develop a new launch vehicle, though, it seemed appropriate to us that it should be one that offered new capabilities in terms of payload, growth capability, and flexibility and reliability, and redundancy. And we found our committee trying to design such a vehicle in our hearings. Most of our members are engineers and we were enjoying ourselves thoroughly designing this new launch vehicle. And we kind of finally shut down and took ourselves aback, and said that is not why were are here. That that is really NASA's job.

So, we really tried to prescribe the requirements for that launch vehicle rather than the details of its design or the details of its cost. There is a trade that has to be made that we did not make, that we essentially turned to NASA with. And one trade is that you would like to have the vehicle soon so that there is less period of time that you are totally dependent upon the shuttle. We clearly will be somewhat dependent upon the shuttle to do unique things for the indefinite future. So, the sooner you get a launch vehicle, the more that helps. And that argues to taking an existing launch vehicle and making a rapid derivative from it.

On the other hand, one would like to introduce new technology so that you have a launch vehicle that has a long life expectancy in terms of being very capable. And that takes more time and more money. The numbers we saw were a range of between $3 and $10 billion at the time we did our work, and that was a very rough order of magnitude estimate because there was not much work

done. And the time scales we saw, as I recall, were between, I think, it was 4½ and 10 years.

And so the system that Admiral Truly describes is certainly compatible with what we had in mind. It is toward the longer and the more expensive end of the spectrum, but it is not at all inconsistent.

Mr. Chairman, may I say one other thing that I should have said at the outset. I do have a conflict of interest in this area, and I am trying to portray our committee's findings, but I do not want to mislead the members in that regard.

Senator GORE. Having been one who raised the concern about conflict of interests, I would like to say, again, publicly, I have been most impressed with your ability to handle that gracefully and well. So, I appreciate you acknowledging it in that response.

Mr. AUGUSTINE. Thank you.

Senator GORE. Admiral Truly, you say 1999 is the earliest possible date that this proposed launch vehicle would be available. It is not likely to be available by 1999; is it?

Admiral TRULY. It is a budget choice. And the reason that for that year, is the engine development. In any event, even if the budgets force the actual first flight of the vehicle to be in later years, we can address that. But in either case, there are some early technologies and definition, and particularly the engine work—that, incidentally, has already started. There is a facility, a component tests facility under construction at the Stennis Space Center today for the space transportation main engine. And that precedes any new capability in any year.

Senator GORE. Well, I am troubled by this because I got the impression from the Augustine Committee report, and I think a number of people got the impression, that the Augustine Committee was really thinking in terms of a $2 to $4 billion program that would be available before 1999. And what the Space Council is insisting upon is an $11 billion vehicle that is not likely to be available until well into the next decade.

Now if we assume that both DOD and NASA are going to have an extra $1 billion added each year to their budgets for this proposal, then the budget crunch for these agencies becomes even worse. And if you have an $11 billion heavy-lift launch vehicle, plus an extra $2 to $3 billion for essential components of the space station that are not now included in the budget submission, then what we are headed toward is a de facto rejection of the Augustine Committee recommendations, because the money available for the items the Augustine Committee has called highest priority will be used to complete programs that are lower priority. But they are started early on and grow rapidly, thus completely crowding out the higher priority programs.

When you recommended, Mr. Augustine, in your report that we consider diverting funds from the planned additional Space Shuttle Orbiter to enable construction of the new unmanned heavy-lift launch vehicle, that kind of implied the magnitude of funding that you all had in mind.

Was that fair for a reader to derive that, given the fact that a new orbiter would likely cost $2 billion?. A lot of people jumped to the conclusion that maybe your group was thinking along the lines

of a shuttle C. Not specifically, but that program costs between $2 to $4 billion. Or else, you all were recommending without saying so that we divert that money as a down payment on a system that would actually cost 4 to 5 times as much.

It was not the latter, was it? You all were kind of thinking of a $2 to $4 billion vehicle; is that not fair to say?

Mr. AUGUSTINE. I think the fair thing to say is what my colleagues on the committee had in mind was there is a spectrum of possible solutions that depend on what we could afford. We did not know what the future budget would be. Clearly, if the budget would permit it, I think the committee members would have liked to have had the more capable launch vehicle. But we also had in mind if the budget would not afford it, then we should go something that was at the lower end, more akin to shuttle C. And that was the reason for the tie that you mentioned between the cost of a new orbiter and the cost of a launch vehicle.

Senator GORE. But now the Space Council is insisting upon a recommendation that will have the effect of—I would argue that if it is accepted, it will have the effect of rejecting the Augustine Committee recommendations if one assumes that the budget agreement entered into by the Congress and the White House is real.

Admiral TRULY. Mr. Chairman, if I might make one comment. When DOD and NASA met with the Vice President just after the first of the year, and we suggested to him, and he gave us the action to go off and take the Augustine recommendation and look at all options and come back. And so the recommendation that we came back with was not a directed one, and it certainly was not intended to be, at least, a de facto rejection of the recommendation for a new system.

The simple—and it is not simple, that is the wrong word—but the difficult trade is a system that incorporates some new technology and has a great possibility of a large reduction in operations costs per flight in future years, against a system that uses current-day technology, and will have very high operations costs in future years. And since the Nation has not developed a new engine in about 20-plus years—we struck a middle ground, frankly.

We did not go to a clean sheet of paper approach which probably would be an $18 billion development if you went all the way to new technology. So, I think you—but you do characterize it, I think, correctly. I listened and met with the Augustine Committee toward the end of their deliberations, and they were thinking about a system that would have been available earlier. But DOD and NASA together agreed that we needed a system, but an old technology system with very high operating costs would not be in the interest of either NASA or DOD use in future years. And so we came back with a recommendation for a middle ground.

Senator GORE. When you say it was not intended as a de facto rejection of the Augustine Committee recommendations, I accept what you have to say. But to be argumentative for the moment, the Reagan-Bush budgets were not intended to add $3 trillion to the national debt, but they did with the acquiescence of the Congress. Similarly, if one takes a careful and responsible look at what the numbers show if the Congress acquiesces in this set of recommendations, even if it is not intended, it will have the effect of rejecting

the Augustine Committee recommendations that programs like Mission to Planet Earth, and space science generally, be assigned the highest priority.

We have, and I include the Congress in this, we have deluded ourselves into imagining that some source of new money would magically appear to solve the budget deficit problem and moot the conflicts that come out of the budget proposals. We have deluded ourselves that some magical source of new funding will save us from the necessity to set priorities in the Space Program. And we cannot do that any more. We cannot do that any more. So, this is my difficulty here.

Let me shift gears, briefly, and then recognize my colleagues again. One of the recommendations of the Augustine Committee—and again, this is one we touched on briefly, Tuesday—Mr. Augustine, you recommended without any reference to personalities, and that is genuine, there is no feeling about individuals at all. But you recommended as a matter of structure, that it is unwise for NASA to ask one of Admiral Truly's assistants to be in charge of both the Shuttle Program and the Space Station Program.

First of all, was that a unanimous recommendation. And if so, why did the committee make that recommendation?

Mr. AUGUSTINE. It was a unanimous recommendation of the committee, and there were several reasons we felt that way. The first is that those two programs comprise an enormous part of NASA's overall program, NASA's management challenge, and it seemed to us that to control those two programs placed almost superhuman demands on an individual, and I speak again without regard to the individuals involved, who I have very high regard for.

It did seem to us, in addition, that the two programs have rather incompatible demands in terms of talents, skills, and time pressures. On the one hand, the space shuttle demands concern about next week's launch, the parts for it, the checkout, all the processing, the details of next week. The other is addressing the question of placing something on orbit in 1996 or 1999, and its basic design, its—rather, its configuration engineering, architectural work.

It just seemed to us that the two demands were different in terms of kinds of skills, time demand, in terms of where do you apply your attention, and when we thought back to our own past experiences, when we have been placed—and some of us had, in that kind of a position, one tends to worry about next week's problem, and that usually turns out in the long term to be a disservice to the longer term project.

So, there was really nothing very profound about our view. That was just a conclusion we came to.

Senator GORE. Admiral Truly, this is one of several instances where the Augustine Committee bit a very hard bullet, and showed some courage and leadership in speaking the plain truth, as I see it. I agree totally, wholeheartedly, with what this committee is unanimously recommending to you. Are you ready to bite that bullet?

Admiral TRULY. Well, if you notice on the tracking of that item, it says that NASA concurs with that, and underneath that it says, "define" in parentheses.

Senator GORE. I did notice that.

Admiral TRULY. So, my answer to you would be, when I understand the result of this study so that we can protect the safety in the shuttle operation, and I get an input from the associate administrators that I gave the action to, which is Dr. Lenoir, Office of Space Flight, and Mr. Force, who is the Office of Space Operations, which was another part of this same recommendation, I am going to make a final decision.

It is our intention to go in that direction, but I just do not have all that data in front of me yet, and I am not going to do anything that would fracture the management of either program, because we have what I think is the best risk assessment and risk management program possible in place in the shuttle and we have finally gotten the station program properly defined.

If I might—and therefore, I concur with it, but they have not reported back to me. But that is the direction I intend to go.

If I might make an editorial comment, though, the reason that those two programs were put together was from my personal experience, because I had the responsibility for the Space Shuttle Program and transportation in NASA. Working for Dr. Fletcher, another individual had the responsibility for the space station.

The fact is, and my view at that time was, because they were working for two different people they were not getting integrated in the planning, and that was one of the things that was preventing the Space Station Program from being properly brought under control, and I think we are now in a very different situation today, and so it is my intent to move forward on that recommendation. It is just—as you will notice, it is this summer at the earliest before I get any detail about offices, moving money, and what the structures would be.

Senator GORE. Well, if you are tying yourself to the ability of an individual who is already overburdened with both the Shuttle Program and the Space Station Program, to find additional time to provide you with a thorough evaluation of a proposal that will take away one-half of his own responsibility, you may be waiting for a while, and indeed, summer may be the earliest.

But decisions are being made right now about these two programs, and you get my point here. I want you to interpret this as pressure to do what the Augustine Committee has recommended, notwithstanding the fact that it is hard for you to do it, and that you have to get the advice and recommendation of individuals who are greatly affected by it, but this is for you to decide, Admiral Truly, not for them.

Senator Pressler.

Senator PRESSLER. Let me follow up with a question out of the report of the advisory committee regarding the issue of management turbulence, because I think that is probably what Senator Gore's line of questioning about the budget and the advisory committee's—the difference between what we say our goals are and what OMB says they are.

There seems to be in the Space Program, from top to bottom, really struggling with—the administrators must not know what is coming next, and you mentioned—you used the term "management turbulence," defined as continual changes in costs, schedule goals, and turbulence is most often the consequence of unforeseen techni-

cal problems, lack of design discipline, and unrealistic budget forecasting, but I think there is a lot of management turbulence—that is a good term—in a lot of our scientific and research efforts with universities in all fields, medical research, and so forth.

As you point out, there are people who spend a lot of time filling out forms, applying for grants, and then the grants do not materialize, or something happens in our annual budgetary processes.

How much of this management turbulence is the fault of the White House and Congress, just in not giving a clear signal? Now, it is true that this advisory committee report is a beautiful blueprint, but as my colleague has pointed out, there are already different signals from OMB, and from here and there. It depends on how you read them. Does this result in part of the management turbulence the report talks about?

Mr. AUGUSTINE. The turbulence that the committee referred to has a lot of sources of its cause. Obviously, NASA does not set out to create a science project that it intends to keep changing. I mean, that is not the intent of anybody.

But the thing that drives turbulence more than anything else, in our view, was the budget process—the availability of funds—and the problem there usually occurs in one of three areas.

One is that the individuals performing the project underestimate what it is going to cost. The second is that the program has problems of some type that just could not have been foreseen that demand more money, and we do not provide generally adequate margins to accommodate those unknowns, and the third is that just the top-down budget process gets changed. The OMB changes it, or the Congress changes the budget.

All this may be for a very good reason, but to that poor researcher out at a university who is trying to carry out a project and have a piece of hardware ready to fly on a given shuttle, and to get someone in a position to qualify for a Ph.D. in a certain amount of time, it is really devastating.

We had many people speak to our committee from the scientific community, and this was one of the principal problems they alluded to, is the inability to really stick with their schedules and their goals. I think they are at fault, in part, for that problem themselves, but really the core of the difficulty lies in the budget process.

Senator PRESSLER. Thank you.

Senator GORE. Senator Bryan.

Senator BRYAN. Thank you, Mr. Chairman.

I note, Admiral Truly, that there is a 17-percent increase in your budget in the area of education, as you have categorized it in your prepared testimony. Could you tell us what that is?

Senator GORE. May I suggest, Senator Bryan, that Mr. Augustine will have to leave shortly for a plane, and if we have—I have some more questions for Mr. Augustine before he leaves. If you have questions for him, I would recommend that we pursue those now and then come back to the questions for Admiral Truly.

Senator BRYAN. Let me do this, Mr. Chairman. I can submit to Admiral Truly some questions. I am going to have to go to another meeting at 11 a.m., so let me yield back my time, and if you will

keep the record open on this subcommittee proceeding, I can submit a few questions to Admiral Truly that I would like to.

Senator GORE. I appreciate your courtesy very much, Senator Bryan. I will conclude my questions as briefly as possible for you before you have to leave, Mr. Augustine.

The advisory committee concluded that NASA was, as Senator Pressler mentioned, oversubscribed. In your view—and the fact that you and other members of the committee recognized this was yet another accomplishment of your study.

In that regard, in your view, would the Congress be better positioned to understand NASA's projected budgetary needs if NASA was required to submit a long-term budget covering 5 to 10 years, for example, annually to the Congress?

Mr. AUGUSTINE. I am probably walking into a political problem in answering this, but it seems to me that it would be sensible for the Congress and NASA, the administration and the public, to have some sense of the long-term budget, realizing, obviously, that as one looks further to the future, there are greater uncertainties. But I would think that would be a very valuable thing to have.

Senator GORE. Well, I appreciate that response.

Now, you and your committee, as is well-known, said that space science should be the highest priority; correct?

Mr. AUGUSTINE. That is correct.

Senator GORE. What exactly does that mean when we look at funding issues. Should they be given priority in terms of funding?

Mr. AUGUSTINE. I think we chose the words that space science should enjoy no less than the current percentage of the NASA budget, and that was on the order of 20 percent, if I remember correctly. It was our hope that as the NASA budget grew by whatever percent might be possible, that space science would share at least proportionately in that growth. By the same token, obviously, if the NASA budget is reduced, we would not expect that everything else would disappear except space science.

We hope to be able to, in addition, build a little insulation around the science programs so that problems that occur in other major projects do not spill over and cause budget reductions and schedule changes in the science project, so we were interested not only in the budget, but in the way they are handled.

Senator GORE. Now, I would assume that the Earth Science and Applications Programs, most notably the Mission to Planet Earth Program, are a part of that high priority; is that correct?

Mr. AUGUSTINE. That is generally true. There are some aspects of the Mission to Planet Earth Program that I suspect would not be pure science, but I think your comment is generally true.

Senator GORE. In fact, the advisory committee stated, and I quote from your report, "While we emphasize the need for a balanced Space Program, it is the Mission to Planet Earth which connotes some degree of urgency."

You stand by that remark; do you not?

Mr. AUGUSTINE. That is true. It was hard for us, as enthusiastic as we are about a mission to Mars, and a long-term manned program, it was hard for us to build a case that you had to meet a given calendar for that mission, whereas the Mission to Planet Earth, you do address environmental issues and other things that

have greater time pressures. But I would again emphasize, just for clarity, what you said, and that is that we did want balance, even in spite of that.

Senator GORE. Would you say, then, that based on the priorities you outline, and based on the language of the report, that in terms of relative priorities, Mission to Planet Earth is a relatively higher priority than Space Station Freedom?

Mr. AUGUSTINE. I think we would only agree with that in the sense of time urgency. In terms of time urgency, that is probably true. I think our committee would have been very disappointed, though, if we had to have a program that had only one and not the other, whichever direction it would go.

Senator GORE. Indeed, you resolved the potential conflict between Space Station Freedom and other parts of the Mission from Planet Earth with the higher priority placed on space science, including Mission to Planet Earth, by adopting this formulation of "go-as-you-pay."

Specifically, you concluded that Mission from Planet Earth Programs, including Space Station Freedom, be placed on a go-as-you-pay basis. In a more constrained funding environment, where would you recommend the space station be in a prioritized list of projects to receive scarce dollars?

Mr. AUGUSTINE. Really, to answer that requires a knowledge of how many dollars are available.

Senator GORE. That is part of the problem, also, but go ahead.

Mr. AUGUSTINE. Well, let me do my best to try to convey what the committee had in mind. We did, indeed, believe that space science should have first priority.

We said that the Mission from Planet Earth, while we think it is awfully important to do—we are very supportive of it—we think that if there is to be a manned space program at all, that the space station is essential to that. It is absolutely the next essential step.

But having said all of that, we really could not build a time schedule urgency for the Mission from Planet Earth, so in that regard one would expect that some things in a Mission to Planet Earth would have a higher priority than the things in Mission from Planet Earth, the latter including a space station—which again is not to say that we would have been at all happy with all of one and none of the other.

Senator GORE. Senator Pressler, I am prepared to excuse Mr. Augustine to get his plane, if you do not have another——

Senator PRESSLER. Absolutely.

Senator GORE. Admiral Truly, if you can stay just a short time longer, we would like to pursue a few other matters. But I know you have a plane, Mr. Augustine, and we deeply appreciate your appearance here today, and again the outstanding job you and your colleagues have done on the committee.

You have heard much praise, but it is all heartfelt, and I hope you will pass it on to the hardworking members of your committee. We look forward to working with you in the future. I know that you welcomed, as I did, Admiral Truly's suggestion that your group consider getting back together with top management at NASA at some point in the relatively near future to go over the progress of

implementing these recommendations. Again, thank you very much for coming.

Mr. AUGUSTINE. Mr. Chairman, thank you, and if I just might acknowledge the appreciation of our committee to you and your committee members and your staff for being willing to spend time with us when we were actually doing our work and sharing your concerns, it was very helpful.

I also should say that our association with NASA in this period could not have been better. We visited every center, talked with hundreds of NASA people, and in terms of openness and candor, we could not have asked for more.

So, I thank you very much, and I will excuse myself, then.

Senator GORE. Thank you very much, Mr. Augustine.

Admiral Truly, I do not anticipate that we will take much longer on this, but do you—you do agree, as you have said, that space science should be the highest priority for the Space Program; correct?

Admiral TRULY. Would it be permissible for me to get J.R. Thompson and Mr. Campbell to step up?

Senator GORE. Surely. We would be happy to have them join you.

Admiral TRULY. But as they come up, let me speak to that. Rather than answer that question with a "Yes," I would prefer to answer it by stating the entire recommendation the way that Norm just stated it himself. The recommendation reads that the Civil Space Science Program should have first priority for NASA resources. But there is not a period there; there is a comma. And it says, and continue to be funded at approximately the same percentage of the NASA budget as is present.

The reason that I point that out—and it is not an argument coming from me about the priority of the Science Program—but simply to allow me to make the point that if we had to take a very large budget cut in the Space Program, it would become unbalanced very quickly if the science programs were totally isolated. I use the analogy that if the Space Program is a piece of cloth and the Science Program is gold thread in that cloth, then the transportation and people and facilities are steel threads that make it possible.

For example, in Dr. Lenoir's budget in transportation, over 50 percent of his budget goes directly to support space science missions. And so with that caveat, and I appreciate your giving me the time to make it, I certainly would agree about the priority of space science.

Senator GORE. I think that is a useful elaboration. Now, that, however, is not the only section of the Augustine Committee report which addresses the underlying issue of how to set priorities where space science is concerned.

Admiral TRULY. That is true.

Senator GORE. And specifically, the committee told the country that when looking at the Mission to Planet Earth and the Mission from Planet Earth, if in any given year one has to make a choice as to when to proceed urgently with one and perhaps delay the other, priority is to be given to the Mission to Planet Earth. Do you agree with that?

Admiral TRULY. I do, and I think in the administration we faced up to that in the OMB when we deliberated this budget. For exam-

ple, the funding for the Mission to Planet Earth, although it has been adjusted from last year for various reasons, is fully supported. The EOS–A instruments have been identified. We are doing an engineering study to look at the program. Nevertheless, it is moving full steam ahead, whereas the Mission from Planet Earth in this budget was reduced significantly.

Senator GORE. It appears to have been reduced significantly.

Admiral TRULY. Well, I believe that it was reduced significantly. Nevertheless, it still remains in the program as a requirement for those focused technologies to make a future program be able to be defined and eventually, in the next century, to be achieved.

Senator GORE. Now, you said in referring to Mission to Planet Earth that OMB adjusted it. Could you be more precise? How did OMB adjust the Mission to Planet Earth?

Admiral TRULY. Tommy, you want to——

Mr. CAMPBELL. Yes.

Mr. Chairman, there was a reduction that we really worked together with them on. So, the adjustment came out of the budget process where our initial estimate for 1992 was just above $18 billion and was reduced to the current value that you have, the $15.7 billion. In that process, we worked rephasing the EOS, and we reduced it by about $80 billion—a little over $80 million. In that same process, the Mission to Moon/Mars was reduced about a $500 million or more.

Senator GORE. Yes. Now, this Mission to Planet Earth which the Augustine Committee said is the one mission which must be approached on an "urgent" basis is now being stretched out by OMB; correct?

Mr. CAMPBELL. Yes, sir. But we focus mainly on the instruments. The instruments doubled in this budget from last year, Mr. Chairman.

Senator GORE. But it does not seem to me that the administration is in agreement with the Augustine Committee recommendation. The administration seems to be, if OMB is forcing NASA against its wishes to stretch out the Mission to Planet Earth and delay the implementation of that program, then it is at least in part, rejecting the Augustine Committee recommendation that Mission to Planet Earth be handled on an urgent basis.

See, what I am worried about is that the hard-nosed priorities set by the Augustine Committee will be praised and acknowledged with gratitude by the administration, but then effectively rejected, in part, as it pursues its own preconceived set of priorities, with the points of conflict camouflaged with stretchouts and extra amounts of money for programs that NASA puts priority on that the Augustine Committee does not, put into a category that enables them not to show up in the actual formal budget submission, but requires that they be spent because the downpayments are made and the programs are started. And then we find ourselves a few years hence with the de facto rejection of the priorities set by the Augustine Committee.

I think we are seeing the beginnings of that process in what OMB has required you all to bring to the Congress this year. The beginnings of a deemphasis and stretchout on Mission to Planet Earth, and the beginnings of a whole series of significant increases

in the programs that the Augustine Committee said should be a lower priority. In the past, the Congress has looked the other way and said, "We can do it all. We will approve all of this. You all go ahead and do what you have in your plans to do, and we will pretend the money will be there." And then we come to the crunch, and we say, "Well, let us just stretch everything out and let us scrimp and save on everything." But we cannot do that anymore.

Now, at the same time OMB cut $100 million from the Mission to Planet Earth, it kept $100 million for the Moon/Mars mission. Is that about right?

Mr. CAMPBELL. It is about $94 million, but $35 million of that is in the science budget, Mr. Chairman.

Senator GORE. Yes, but the effect is that the White House has reversed the Augustine Committee priorities.

Mr. CAMPBELL. No, sir. We thought we were endorsing it because they emphasized life sciences also. And the life sciences budget has a substantial increase.

Senator GORE. But again, Mr. Campbell, that is one of the sections of the Augustine Committee report. The Augustine Committee was quite clear and explicit on the relative priorities of Mission to Planet Earth and Mission from Planet Earth. And the budget goes to OMB and the Augustine Committee priorities are exactly reversed—$100 million is cut out of Mission to Planet Earth and put into Mission from Planet Earth.

Admiral TRULY. Mr. Chairman, if I might comment.

Senator GORE. Yes.

Admiral TRULY. The Augustine Committee has been complimented on making hard choices, and they certainly did. But they made their hard choices in a budget they made up, which was a budget assumption of a 10-percent real growth per year. The choices that you are talking about that were made not unilaterally by OMB, but in a budget negotiation with them last fall, which occurred, quite honestly as I recall it, before the Augustine report was made, although later tweaks were made to it.

And the thing that drove it was not a made-up budget, but a real budget, and that was the appropriation we got in 1991 with its attendant projected runout and the difference. The runout from last year's NASA budget that was in the OMB books for this year, for 1992, prior to the appropriation was $18 billion. When we got a reduction last year, the runout for 1992 was reduced from $18 billion to where it ended up being at $15.7 billion. And frankly, even that was up for debate for quite a while in the fall.

Therefore, adjustments were made across the board in transportation, in Mission to Planet Earth, in Mission from Planet Earth, in space station, and there were puts and takes across the board. We feel like—and I still believe that we strongly support Mission to Planet Earth. Certainly any human being that has flown and looked at this Earth puts a very high priority on that. And it did require an adjustment in that line, as it did in many others. But a far larger adjustment was made in the technology programs that lead to Mission from Planet Earth.

Senator GORE. Now, in fairness to the Augustine Committee, you say that they made their choices in the context of a made-up budget that is not real.

Admiral TRULY. An assumption, yes.

Senator GORE. Yes. In fairness to them, they made an even harder set of choices when they addressed the possibility that their budget assumptions would not prove to be attainable. They told the country, if we do not have the amounts of money that we would recommend the country assign to this, 10-percent real growth per year, then here is what we believe the priorities ought to be in that real budget environment.

And the implications there were even starker for the Mission from Planet Earth. Do you agree with—I mean, they said, if the money is not available then what do we do? We pursue Mission to Planet Earth on an urgent basis and we stretch out Mission from Planet Earth and pursue it on a go-as-you-pay basis. Is that your reading of the report?

Admiral TRULY. Yes; and it is my reading of the budget submittal as well.

Senator GORE. I respect your interpretation of it. My interpretation of the submission is not precisely that. My interpretation is that they did the reverse. They did take money out of Mission from Planet Earth. I acknowledge that. And since there was a lot more money there, they took more money out of there.

But they stretched out Mission to Planet Earth and they put money back in for the Moon/Mars mission, which the Congress had said, "Look, we would like to do this, but it is a lower priority right now, given the situation we face." And the Congress had cut that out. Almost the same exact amount of money they had cut out of Mission to Planet Earth to stretch that out, they put back into the Moon/Mars mission in order to get that started earlier than the Congress believes is reasonable and feasible.

So, this is something that we are just simply going to have to take into account when we review the budget submission this year, and I am happy to get your views on it. But if you want to comment further on that, you are welcome to.

Let me say that where Mission to Planet Earth itself is concerned, we are going to be focusing quite closely on that program here in the subcommittee, as you all are in NASA as well. I conducted, along with Senator Mikulski, several roundtable discussions with the leading scientists in this country in the earth sciences fields to get their informal review and recommendations of what Mission to Planet Earth really ought to look like. Some folks from NASA were involved in that. Some of your advisory committee people were involved in that.

The process for us is not completed. What has come out of it thus far is a set of priorities that seem to me to be different from the ones that are in the program now. Given the fact that you have the whole program under review, I am not going to press you too hard on defending the ones that are in it right now. But I would note that the Augustine Committee recommended that the programs under NASA's Mission to Planet Earth be conducted as a continually evolving mission rather than a mission whose design is frozen in time.

How do you interpret that language, Admiral Truly? And given NASA's commitment to the larger Earth Observing System plat-

forms, is there enough flexibility in this program to allow for change?

Admiral TRULY. I think there is. I think Dr. Fisk would be a much better person to give you a brief answer. Incidentally, I would like to thank you for conducting the hearings that will allow this Mission to Planet Earth, in these various debates, come to a program that does serve those needs. In the bottom line, I agreed with that recommendation of the Augustine Committee; however, there are tough technical choices to be made, and therefore a study will be underway.

But I believe Dr. Fisk could put it in much——

Senator GORE. May I say, before Dr. Fisk responds, that, of course, as you know, I have a personal interest of longstanding in seeing our Nation lead the way in defining what must be done to respond to these unprecedented global environmental problems, perhaps most especially those affecting the degradation of the global atmosphere.

We had just last week another warning bell of how serious the problem has become as a result of NASA scientists analyzing satellite data that give a much more accurate view of what is happening than anything ground-based scientists can provide.

I would just like to say this—and I know you all are aware of this, but the country responded to NASA as an agency during the Apollo era because NASA was helping humankind fulfill a dream, and did so so incredibly well that the country's pride in NASA just knew no bounds. And of course, the country is still so proud of NASA. Now, partly as a result of this feeling of urgency that the Augustine Committee cited, the country is again looking to NASA, this time for a different kind of mission.

I truly believe that the near- and mid-term future of NASA really will depend to a large degree on whether or not the agency is able to adjust and adapt itself to a wholehearted commitment to making this the number one priority for NASA. The Augustine Committee, for related reasons, also urges NASA to it the No. 1 priority.

I will just tell you—and I do not want to ask you necessarily to respond to this, but I will just tell you what my own impression is. I think that men and women in NASA understand that, are committed to it, and want to see that happen. But I think as an institution NASA, is experiencing tremendous difficulty in making that adjustment.

I think the inertia that naturally attends the development of very large and expensive technology programs tends to focus energy, money, emotional commitment to these large programs, some of which were started for other reasons, some of which represent genuinely the best first stab at what we—that is not even fair—the best effort in the early stages of thinking through Mission to Planet Earth, what can NASA best do?

And large, expensive platforms, for example, tend to coalesce people who are especially interested in seeing those proceed. And there is nothing wrong with that. But NASA faces a threat institutionally from the natural forces that tend to drive it toward that kind of program. And in fact, the flexibility to adjust must be preserved if NASA is going to be able to play this historic role that the country now wants it to play.

We are going to have a hearing next Thursday on the National Academy of Sciences report with Frank Press, Dan Evans, and Dr. Allen Bromley, among others, to talk about the new global warming part of Mission to Planet Earth. And I anticipate there will be other roundtable discussions of the kind Senator Mikulski and I had last year on an intensified and accelerated basis, in conjunction with the hearings our subcommittee will have, in order to try to assist those in NASA who are taking the lead in thinking through how this program can be modified and evolved.

Dr. Fisk.

Dr. FISK. Thank you, Senator. You and I are going to have a hearing, I think, next week, and I will give detailed answers to a lot of the issues you raised.

But please be assured that NASA's Mission to Planet Earth is designed to respond to the science input. I do not even like large satellites, personally. I mean, we do this simply because after the 7 years of planning that has gone into this and the some 500 scientists who have set the requirements, this is how we got to where we are. And we will be happy to talk to you in detail on that.

Senator GORE. Right.

Dr. FISK. On your specific question of evolving technology, I think the issue is addressed primarily to one of Do you fly the same instrument over and over again, or do you allow for evolving technology? And I think we have a plan to address that, which we will be happy to talk to you next week about.

Senator GORE. I look forward to going into great detail with you on that at the hearing next week, one of two hearings on the subject next week.

The external review of the EOS program, just to follow up briefly, is not to be completed until later this year; is that correct?

Dr. FISK. That is correct. The due date is September 30.

Senator GORE. Now, that puts us in a difficult position in acting on the program this year if some of the budget items involve commitments to elements of the program which may change based on the external review.

Dr. FISK. The primary thrust of the review is to look at the follow-on A series platform, which is essentially the question you raised about evolving technology, should all the platforms be the same? And the B series, which follow-ons to the A—the committee will, of course, look at the first of the A series, which is under construction now.

Senator GORE. The external review is not designed to look at the entire Mission to Planet Earth program, but just the follow-on——

Dr. FISK. Let me answer that carefully. They are to look at the whole program, but the recognize, as we do, that the first of the A series is under construction at the moment and we do not want to do anything that would delay the program. I mean, we share the same sentiment we all have on this that the idea is to get this up as soon as possible. And so they will look at it, but—and we, of course, always welcome advice, but only in the event that there is something significantly better than we are currently doing would we anticipate making any changes. So, this is not primarily a 1992 budget issue that they will be addressing, because there is very little in the 1992 budget associated with follow-on A or B series.

Senator GORE. Now, the House Space Subcommittee, in its initial markup, concluded that the EOS program is, and I quote, "not sufficiently resilient" with respect to future budget decisions. What plans does NASA have to ensure that this top priority remains so? Do you think the House committee was—do you want to take issue with that?

Dr. FISK. I would certainly take issue with it. I think the budgets that they suggested for the program, particularly in the out-years, would cripple any reasonable global change research program. I am sure you are very much aware that if you want to study a planet as complicated as the Earth, it is a major research effort. By your own statements, this is something that will require considerable funding in order to execute properly.

Senator GORE. Well, I personally disagreed with the House number on that one. I greatly respect their judgment and expertise and ability, and also have some hope that they will work with us in the process, because we are really going to be digging into that and maybe we can help you with that one.

Now, Dr. Fisk, just following up on Mission to Planet Earth for one other moment here, if we fund an extra $2 to $3 billion of add-ons to the space station beyond what we have in the budget submitted, if we then crank up an $11 billion heavy-launch vehicle between now and the deployment time for EOS, are you a little bit concerned that the money for your Mission to Planet Earth might be in jeopardy?

Dr. FISK. That, of course, is an awkward question for me to answer, Senator. Let me state it the other way around. In the budget submission that you have before you, the Office of Management and Budget, there is a runout budget for the EOS program which is adequate to do to the program. It will get the A series up and a reasonable B series and follow-on A's. And most important, the data and information system is funded.

Now, if for whatever reasons we are not able to achieve that budget, then the program is damaged. And as we have said in other occasions—other settings, you know, the thing about EOS is it is a very simple issue as to whether—if you do not get the money to do the program then you do not measure something.

And as you well know, the understanding of the Earth's interaction system is something—we need to look at a variety of parameters in order to make sure that nothing got past us in trying to predict the various feedback mechanisms which are going to control the climate.

So, the threat that I always worry about in this program is if the funding is not there, then we will have to make some decision not to measure something, and that will be a very difficult decision to make because our understanding of the Earth is not sufficient to say what is, in fact, going to be important to understand.

Senator GORE. Admiral Truly, if we undertake the new heavy-launch vehicle and the crew return vehicle, the extra kilowatts for space station, the other modifications that we talked about at least twice this week, and all that that goes into your budget throughout the remainder of this fiscal decade, Mission to Planet Earth is going to be hard pressed to get funding; would you not agree?

Admiral TRULY. I think the total NASA budget is going to be under great pressure over these coming years; however, I must reiterate that I think that as we jointly face and make these tough decisions, we are going to—it is in the Nation's interest to keep a balanced program. And therefore, I believe it is my responsibility to bring to the Congress a balanced recommendation.

But the direct answer to your question is, all programs will see this pressure and priorities will have be chosen. I am very proud of our Mission to Planet Earth Program and our contribution to the Total Global Change Program, and I believe that in this budget we have requested moneys that I hope are achievable. And we are going to intend to keep that program at the top of our viewpoint in the front office to make sure that it is not only funded but also executed and delivered in the manner in which we plan it.

Senator GORE. If you faced a decision to come up with additional money by either delaying space station and the heavy-launch vehicle start or stretching out and delaying Mission to Planet Earth, which would you choose?

Admiral TRULY. I just cannot imagine a situation that I would have to face a stark—such a stark decision, but I can tell you this. If we do, I would face whatever budget level appears to be a reality and make a specific recommendation. I would attempt to keep a balanced program, and I would not back away from a strong support for Mission to Planet Earth.

Senator GORE. Even if that meant delaying space station and the heavy-launch vehicle?

Admiral TRULY. The space station—if I might draw a distinction between those two, the Space Station Program, I believe, is at a point where the Congress is going to have to decide whether or not the commitment that we have brought to the Congress, since it was based on a set of funding assumptions that were given to us—whether or not space station should go forward.

We believe very strongly, as you know, that we have done what I think is a very good job, and we have kept the international partners on board throughout this. We have done all those things in station to bring the program under control. We have downsized it, we have reduced the transportation, and so forth.

To stretch it out is simply going to escalate the cost of the program, because we are today at a—I am not sure if we are at the peak, but we are very close to a peak of manpower. We are in a year of critical design review. And my point was going to be that that is a very different situation than we are in the new launch system, which is a proposal for something we believe very strongly in but can be started at a much lower level, and particularly to keep the engine development working.

And in this same hearing room a decade or a decade and a half from now, I hope there are still debates about a strong civil space program going on. And in that case, the failure to have started some new technology in the launch business I think will be viewed as a mistake.

I do not envy you the terrible choices that the Congress has to make this year, but last year was not easy either and neither is next year going to be. I just feel so strongly that the investment in the Civil Space Program is one that is worth it for the country

that—I have to believe that the balanced program that the Augustine Committee brought forward can be funded at a effort that will not require killing one of the little brothers or sisters to the total success of one of the others. Mission to Planet Earth is vital, but the Manned Space Program is vital to our country too.

Senator GORE. I think that is an excellent response. The phrase "go-as-you-pay" has to be interpreted differently when you are at a decision point on a program that has already been redefined and restructured and study and restudied. I agree with your decision to separate those two in your response.

Where the heavy-lift launch vehicle is concerned, given that terrible and hypothetical choice, you would say, as I understand your response, go forward with Mission to Planet Earth, stretch out the heavy-lift launch, but in doing so you would say, look a few years from now we may say that is a mistake because this is a program that is needed. But given the terrible necessity, if that should arise, to make that choice, that is the one you would make.

Now, where the space station is concerned the choice appears a little differently. You really, on that one, have to look at the full cost and then decide whether this space station should go forward or not. The delay option, the stretch-out or go-as-you-pay option where space station is concerned really means to scrap this one and come up with another one at a later time, perhaps one that took advantage of the new heavy-launch vehicle when and if that appears. And none of those options appear attractive.

I appreciate your sympathy when you say you do not envy the decisions Congress is going to have to make this year on that. But I will just say that because these are such terrible choices, it makes it especially important that we do get a clear picture of the full cost of this space station and all the budget implications for the other options on down the road. I am not going to get back into that. We have been around that barn several times. But it is especially important to us to have that for that reason.

Now, NASA's restructured space station design and assembly launch sequence assumes the integration of the advance solid rocket motor, beginning with flight 6 in December 1996. As you know, ASRM is expected to add some 8,000 pounds of additional thrust, increasing the shuttle's payload carrying capabilities as well as its margin of safety. Yet, according to NASA's budget for fiscal year 1992 the request for ASRM falls well short of the amount needed to ensure that it will be available by the scheduled December 1996 date.

Can you help me better understand how this discrepancy in the budget figures has occurred?

Admiral TRULY. Let me give you a brief answer and then ask Dr. Lenoir to follow up. There has been some cost growth in the program that we see in the 1992 budget. And we have identified the approximate size of our requirement in 1992 as I have gone through the committee process. It is approximately $125 million; however, the advance—I would also say that the Advance Solid Rocket Motor Program remains a very important program within the Shuttle Program, and we have baselined it as you described in the Station Program.

In the event that the ASRM did not make that particular flight that you referred to, we do have a work-around plan in which we would plan a logistics flight in that spot and not lose—it would not be a significant disruption to the space station assembly sequence.

If I might ask Dr. Lenoir to change anything I said or remark about it, I would like to do that.

Senator GORE. Dr. Lenoir.

Dr. LENOIR. The only thing that I would add is, going back through the process, it is important to realize the sequence within which the events unfolded. Our 1992 budget was submitted first to OMB and then discussed and agreed with OMB as to what would be submitted by the President. And then after that, the space station restructuring effort was completed.

At the time the 1992 budget was submitted and was in a sense finalized, the timing and the needs of the space station were not known. We took what we felt was our best guess. And in retrospect, we have a scheduled disconnect between the first desired use of the advance solid rocket motor and the time that it would apparently be available by the requested budget. And we have a study going on that is nearing completion now to assess what would the advance solid rocket motor need in order to meet the space station schedule.

Senator GORE. That is a clear response. Very helpful to us. Can you give us an estimate of how much more will likely be needed in fiscal year 1992 to keep this ASRM program on the 1996 schedule to fit in with the restructured station design?

Dr. LENOIR. Yes. Our current estimate is, it will be between $100 and $150 million, most likely near the middle of that range.

Senator GORE. So, that is where your $125 million figure came from earlier.

Dr. LENOIR. Yes.

Senator GORE. OK.

Now, if Congress cannot add the ASRM funds that the administration failed to request, a surprising situation given claims that it needs ASRM to support the space station redesign plan, what fallback position would NASA establish then?

Dr. LENOIR. In the advance solid rocket motor project we would have no choice but to delay its first use. And that would most likely make it unavailable for the first requirement by the space station, but would allow it to meet the second requirement.

As Admiral Truly explained, that first requirement by the space station is the launch of the laboratory module. That would require us to launch the laboratory module without all of its equipment in it at launch. And we would subsequently follow that with an outfitting flight to launch that equipment and install it in orbit. The preference would be to avoid that.

Senator GORE. How much additional cost would that add to the space station restructuring plan?

Dr. LENOIR. I do not know that at this time.

Senator GORE. Would it be more than $125 million?

Dr. LENOIR. I would not think so. My answer, incidentally——

Senator GORE. What is the marginal launch cost?

Dr. LENOIR [continuing]. My answer, incidentally, did not include the shuttle cost. I was talking strictly the space station cost. That

would be in addition to the shuttle cost. And that marginal cost is, I believe, $60 million.

Mr. CAMPBELL. That is about right.

Senator GORE. The marginal launch cost, I thought, was more than that.

Mr. CAMPBELL. No, sir. It is between $56 and $60 million, depending upon the year.

Senator GORE. And the total, then, with the extra shuttle cost and the extra cost to the Space Station Program would be how much, roughly? Would it approach the $125 million?

Dr. LENOIR. I am certain that it would, because an unintended effect would be to push a couple of the space station flights to the right and delay cost money. So, I would be very surprised if it was less than $125 million total.

Senator GORE. So, it might well be a false savings to not do that $125 million this year.

Now, finally, what are NASA's estimates for the total cost of the ASRM program, and what is the principal cost driver in that program?

Dr. LENOIR. We will have to take that for the record. That is the subject of the study that we are completing next week.

Senator GORE. We will be glad to get that for the record.

[The information referred to follows:]

MAJOR COST DRIVERS FOR THE ASRM PROGRAM

The Advanced Solid Rocket Motor (ASRM) is a new motor incorporating improved reliability through enhanced quality and reproducibility. The ASRM incorporates improved safety margins, reduced critical failure modes, improvement in joint configuration, tailoring of the thrust profile at maximum dynamic pressure during ascent, and automated manufacturing techniques. In addition, the ASRM significantly enhances the performance capability of the Space Shuttle, allowing it to carry heavier payloads to orbit.

A major cost driver in the ASRM program is the manufacturing facility and the associated equipment required to operate the plant. A new manufacturing facility is being constructed on an abandoned TVA nuclear plant site near Iuka, MS. The facility will make use of existing structures to the maximum extent possible and will provide the buildings and automated equipment to assemble and load the solid rocket motors. The nozzle for the ASRM will be manufactured in New Orleans at NASA's Michoud Assembly Facility. A portion of this facility (currently used in fabricating the External Tank) is being converted to ASRM use. The ASRM case will be manufactured in Mount Vernon, IN, where existing facilities (owned by Babcock & Wilcox) are being modified and plant equipment installed.

Other major drivers in the facilitation arena include the construction of a test facility at the Stennis Space Center for full-scale ASRM firings, and modifications to existing facilities at the Kennedy Space Center for processing the ASRM for launch.

GThere are several major drivers in the Design, Development, Test and Evaluation (DDT&E) phase associated with the motor. The ASRM makes use of a weldable case material and a different propellant formulation. Extensive effort is required for material characterization and process development. A comprehensive subscale test program is planned to verify the motor design. Tests include 48-inch motor firings, field joint structural tests, transient pressure tests, and ASRM structural tests. A full-scale series of motor firings is planned in the development and qualification of the motor. Three development and four qualification firings are currently required to certify the ASRM. The DDT&E program includes the fabrication, assembly and launch of six flight sets of ASRM's. In addition, DDT&E includes the initial lay-in of reusable hardware for the program. Also, included is the cost of integrating the ASRM with the other Space Shuttle elements.

Senator GORE. The other questions I have I will submit for the record, because we have had a long morning. And I appreciate your

patience and stamina, especially since this is the second hearing this week. And I really wish you well.

In the coming months we will be talking with you frequently about some of these choices we have talked about here. It is going to be a tough year, but we appreciate the fact that you are there and the team you have assembled, Admiral.

Thank you very much.

[Whereupon, at 11:50 a.m., the subcommittee was adjourned.]

APPENDIX

LETTER FROM MARTIN P. KRESS, ASSISTANT ADMINISTRATOR FOR LEGISLATIVE AFFAIRS, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

MAY 16, 1991.

The Honorable RICHARD H. BRYAN,
U.S. Senate,
Washington, DC 20510

DEAR SENATOR BRYAN: In our April 19, 1991, testimony, before the Subcommittee on Science, Technology, and Space, NASA officials indicated in response to a question you posed, that no funds were being expended for nuclear propulsion activities.

In fact, our fiscal year 1991 Exploration Technology Program includes $500,000 to initiate nuclear propulsion research efforts at the NASA Lewis Research Center in Cleveland, OH. This modest effort is focused primarily on planning activities including studies associated with requirements definition, environmental assessments, and conceptual designs.

I am sorry for this confusion and hope this letter clarifies our response to you.

Sincerely,

MARTIN P. KRESS,
Assistant Administrator for Legislative Affairs.

PREPARED STATEMENT OF THE AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS

The American Institute of Aeronautics and Astronautics (AIAA) thanks you for the opportunity to present our views on the FY92 NASA budget proposal. The 44,000 professional and student members of the AIAA are proud of the contributions they make to the U.S. economic and technological strength. As the nation's leading aerospace professional society, the AIAA is dedicated to the promotion of the arts, sciences, and technology of aeronautics and astronautics. To foster the advancement of the profession, AIAA sponsors numerous technical conferences, workshops, and symposia that steadily advance the frontiers of aerospace knowledge. In addition, the AIAA has published over 200 scientific and technical books ranging from the popular "Augustine's Laws" to our latest book, "Introduction to Mathematical Methods in Defense Analysis." The AIAA maintains an on-line network of aerospace engineering abstracts and is responsible for the publication of the "International Aerospace Abstracts." As of January 1991, AIAA had published over 1 million technical abstracts in over 100 languages. AIAA's public policy activity keeps our members aware of emerging policies and promulgates the AIAA's policy positions.

As we enter a new era of world peace, we recognize that the United States must now turn its attention to a new challenge—that of the competitiveness of the U.S. enterprise system. More than at any time before, we recognize that our future national security, and the other benefits of our society, depend on our economic strength. Given the current fiscal environment, the responsibility of Congress in determining the future of the U.S. civil aerospace program has never been weightier. A succession of reports during the past 5 years has examined NASA's problems, offered visions for the future, and made recommendations. The most recent of these was the report of the Advisory Committee on the Future of the U.S. Space Program. The AIAA supports the observations and recommendations of this report. One of its recommendations is for annual growth in NASA budgets of 10 percent after inflation. The Administration's FY92 budget proposal is somewhat more modest, at about 8.5 percent after inflation.

We recognize that strong pressures to reduce the deficit will encourage Congress to seek smaller budget growth rates, and thereby introduce the danger of trading

long-term paybacks for short-term gains. In considering such compromises, we urge that you be guided by three basic principles:

(1) The space technology base is the foundation on which all future space activities and capabilities depend. Support for that base must not be allowed to decay, even though much of its payoff will come in the future.

The Advisory Committee on the Future of the U.S. Space Program has recognized this key issue and recommended that the space technology base be rebuilt "if a sound underpinning is to be regained for future space missions." Indeed, they called for growth in annual technology budgets by a factor of three.

(2) Long-term programs that evolve over decades should be funded at a predictable and relatively constant level of effort, and their "milestone" goals and objectives used to measure achievement should be defined and set on the basis of that level of effort. This does mean that such programs should be funded out of budget "leftovers," but that they be planned and designed as open ended programs whose annual budgets are agreed upon by the Administration and the Congress. The Advisory Committee suggested such an approach for the Space Exploration Initiative. Note that the space science program has operated successfully on this basis for decades.

(3) In program areas not covered by the above-stated principles, budgets for the completion of existing projects must be held in a proper balance with those for the initiation of new ones. Once a program has been approved and implemented, it should be completed on schedule and on budget. Program delays and stretchouts always increase costs, often reduce system capability, and thereby drain potential funds for new projects.

A well-balanced and vigorous civil space program is key to advancing science and technology and to improving economic competitiveness. Investments in the civil space program help to maintain our economic, political, and scientific leadership in the modem world. The U.S. civil space program is also a key element in foreign policy. The rapid growth in space capabilities overseas means that if the U.S. does not make the commitment needed for world leadership, others will.

OVERVIEW OF SPECIFIC NASA SPACE PROGRAMS

Space Science

Space science missions have been the foundation of the U.S. civil space program, serving to demonstrate the technologies needed for human space flight as well as providing unprecedented knowledge about the Earth, the planets, and the Universe. The Advisory Committee placed its highest priority emphasis on NASA's science program.

Voyager 2 was a prime example of the value space science programs bring in the search for better understanding and increased knowledge of the universe we live in. In addition, it illustrated that long-term benefits can be achieved with a small initial investment and a strong commitment by both the government and the people involved in the program. Besides providing valuable information for human space missions, robot spacecraft planned for the 1990s will help scientists unlock the many mysteries of our universe.

The Hubble Space Telescope, despite its difficulties, is returning valuable data that scientists have waited eagerly for, and after its planned upgrading in 1993 is expected to meet all its projected scientific goals. However, its much-publicized problems have led many to question whether NASA should continue doing "big science" projects. Although the Hubble aberration was certainly a major and unforgivable error, it was an error which the program design will be able to accommodate. Because of that sound overall management approach, which provided for Hubble to be maintained and repaired in orbit, it can fulfill all that was originally expected of it over its 15-year lifetime despite the serious primary-mirror flaw. Nevertheless, NASA has recognized that large programs are particularly susceptible to management problems, and is therefore currently upgrading its management system with an agency-wide training program in project management, system engineering, and project control.

We also witnessed NASA's ability to troubleshoot problems with the Astro mission that flew on the Shuttle in December. Emergency efforts by science and engineering teams, including the astronauts, helped to overcome severe software problems. Because of their exemplary efforts, NASA was able to obtain data otherwise unobtainable on Earth.

Nevertheless, management of science programs continues to concern many of the scientists who often devote their careers to these projects. At its inception, the space science program enjoyed the image of a "Culture of Excellence," but that excellence

is now perceived to have undergone a gradual decay. Restoring it will require that NASA re-examine and reemphasize its partnerships with industry and the universities. Much of the work that NASA conducts in-house might be better done in partnership with these communities.

Another concern is the budget proportions allocated to large, medium, and small missions. Recent deliberations within the scientific community (the Bahcall Committee of the National Academy of Sciences) recommended a re-examination of those allocations, implying that more emphasis be given to the smaller missions. These offer more flight opportunities and shorter development times, which would encourage and attract bright new talent into the science and engineering disciplines and provide training and opportunities for advancement to younger scientists and engineers. This emphasis on "small projects" should also be extended to include the lowest-cost and therefore most frequent flight opportunities offered by research aircraft, sounding rockets, and Shuttle "Getaway Specials."

A third concern of many space scientists is that NASA should be accountable for orderly completion of existing programs, and, as we stated earlier, that completion of such programs be kept in proper balance with the planning and initiation of new ones. NASA project managers, for example, often add new objectives (e.g., new technologies, higher reliability requirements) as a project evolves, thereby impacting cost, schedule, and project goals. NASA should be held accountable for the consequences of these "creeping objectives."

One solution to the accountability of mission cost growth would be to change the current practice in which management decisions are often made in isolation from overall mission costs because some mission elements lie outside the manager's scope of responsibility. The most obvious of these elements are transportation, mission operations, and data analysis. NASA should establish mission accountability practices in which all mission elements are integrated at the outset and managed to completion.

Proper perception of programmatic risk is also essential to the effective conduct of science missions. Hubble and Astro were designed to recognize and deal with the kinds of risks that are inherent in advanced-technology' programs. Certainly, similar risks are posed by programs such as the Advanced X-Ray Astrophysics Facility (AAAF), which will study stellar structures and their evolution, active galaxies, and clusters of galaxies; and the Comet Rendezvous Asteroid Flyby (CRAF)-Cassini mission, a joint mission to Saturn and the comet Kopff. These programs should not be curtailed or compromised because of improper perception of the very real risks they involve. The future scientific return of data from these programs will prove to be invaluable to the scientific community.

One space science project essential to the support of any future exploration initiative is the Mars Observer. The Mars Observer program will augment the data collected during earlier Mariner and Viking missions by mapping the surface composition, atmospheric structure and circulation, topography, gravity, and magnetic field of the planet Mars. This information will help guide decisions on future human flights. Precursor missions with high science returns, such as the Mars Observer, have comparatively modest runout costs, are fully consistent with the Advisory Committee's recommendations, and have great merit even when viewed as individual missions. A similar case can be made for the Lunar Observer; the AIAA deplores deletion of this project from NASA's space science program.

In its report on the EY91 NASA Authorization this Committee directed that NASA undertake two workshops, one to define a program for increasing the detection rate of Earth orbit-crossing asteroids, and another to define systems to alter the orbits of such asteroids or destroy them if they should pose a danger to life on Earth. The AIAA strongly supports this recommendation and will be participating in these workshops.

We also believe that funding for asteroid research has for many years been insufficient to build up the knowledge and capability needed to advance the field at an appropriate pace. We therefore urge the committee to increase funding for the Research Analysis line item in the Space Science budget for research on Earth-orbit-crossing asteroids. Since only limited funds are required, we recommend that this funding not detract from other programs.

The benefit-to-cost ratio of this effort could be enormous. An increase of the order of $2 million could be put to good use in grants for research to detect asteroids, to study their chemistry and physics, to plot their orbits more precisely, and to upgrade equipment. With regard to the latter it should be pointed out that the "Spacewatch telescope" at Kitt Peak National Observatory near Tucson, Arizona, which is dedicated largely to asteroid research, was built in 1921.

SPACE APPLICATIONS AND COMMERCIAL PROGRAMS

One area of NASA's program which has brought major benefits both to the U.S. and to mankind is in the applications of space-derived technology. These have appeared primarily in Earth, ocean, and atmosphere observations for both civil and national-security purposes, in various communications and position-location services, and in biomedical and materials processing. Some examples are as follows:

- NASA's Advanced Communications Technology Satellite (ACTS Program), which has generally been supported by Congress in past years, has helped to launch a bold commercial venture by Motorola called Iridium. The proposed venture will establish a global telecommunication network consisting of a 77- satellite system. This multi-billion dollar program could not possibly go for ward were it not for the ACTS Program.
- Search and Rescue was originally developed by NASA with international partners and is currently run by NOAA in cooperation with many nations. The International Search and Rescue Program has demonstrated the capability of satellites to locate aircraft and marine vessels during emergencies.
- Life Sciences research has assisted in the development of air and water purification systems, aids for the handicapped, and patient monitoring systems. Bio-medical and Materials Processing and other life sciences research may well provide a wealth of direct applications.
- Remote Sensing Satellites, such as Landsat and SpotImage, have been actively used by many nations to monitor weather, marine life, and agricultural development and changes. Most recently, the entire world was witness to the direct applications that remote sensing capabilities had to the "Desert Storm" operations.

Although space applications represent a relatively small portion of the budget, these activities must be strongly supported and vigorously enhanced wherever possible, both in the Office of Space Science and Application and in the Office of Commercial Programs. Such applications could well be the most important contribution of our civil space program to national competitiveness.

The increase in FY1992 funding for commercial programs is one of the most positive features of the proposed budget. Commercial space activities involve industry, government, and academia in a common effort to generate net benefits through the commercial development of space. In the past, AIAA has identified six areas where opportunities for initiating or continuing commercial space development exist: satellite communications, Earth observations, space processing and research applicable to ground-based manufacturing, life science, transportation, and ground and orbital services.

As commercial enterprises increase their participation in U.S. space activities, NASA must play an active role in encouraging and supporting private-sector investments by expanding the agency's traditional practices of funding research, technology advancement, and demonstration of new technology areas having commercial promise, and of helping develop commercial markets by purchasing needed goods and services whenever possible. We applaud the formal recognition of these practices by the Administration's new U.S. Commercial Space Policy Guidelines.

In this context, the AIAA supports NASA's Technology Utilization Program and particularly the Centers for the Commercial Development of Space (CCDSs). The Technology Utilization Program is designed to ease the transfer and application of aerospace technology to the private and public sector. This is a critical endeavor in establishing and maintaining the U.S. competitive position in the global market.

The CGDSs are designed to conduct research aimed at the identification of potential projects. These consortia of government, universities and industry are an excellent mechanism to encourage investment of private capital in commercial space development. It is important that the role of the private sector in these CCDSs relative to that of government continue to grow, and therefore the federal level of budgetary support should be related to private-sector participation. NASA should therefore define specific qualitative quantitative goals to help establish that level of support, and should review the CCDSs periodically to ensure that these goals are met. Furthermore, it is clear that long-term commitments to such goals are essential if commercial organizations are expected to make the investments required for commercial success.

Many of the experiments identified by the CCDSs are dependent on the availability of limited Shuttle facilities. In the past, the AIAA has taken the position that the shortage of microgravity flight facilities is the single most critical factor limiting research in microgravity processing. For this reason we strongly support the proposed budget for the Commercial Experiment Transporter (COMET) expendable

launch vehicle, which will provide long-duration microgravity exposure for commercial payloads. In addition, AIAA applauds NASA's commercial lease of a payload module that will provide pressurized man-tended capability aboard the Shuttle cargo bay. We encourage even greater use by NASA of such commercially developed systems, which might include microgravity simulation aircraft, launch vehicles, and orbiting test platforms other than COMET.

MISSION TO PLANET EARTH

As the nation considers the prospects for exploring space more intensively, it is important that we also continue to expand our knowledge of the Earth as a planet. We are becoming increasingly aware of the delicate relationship between human civilization and the global environment. The effects of deforestation, burning of fossil fuels, and widespread use of certain industrial chemicals on depleting the ozone layer, creating unacceptable air pollution and acid rain, and raising the threat of global warming are of critical importance to human survival.

"Mission to Planet Earth" is a vital program that will enable the global community to understand better how the Earth functions on a global scale. The program will gather data on the Earth's climate and weather, its atmosphere and clouds, its land, its crops, its forests, and its ocean temperature and currents. The information gathered will enable the leaders of our world to make intelligent policy decisions to protect the future of the planet and of our children.

The Earth Observing System (EOS) is the centerpiece of Mission to Planet Earth. The six polar-orbiting platforms which will make up EOS will contain instruments designed to observe the Earth's land areas, atmosphere, and oceans for 15 years and thereby provide scientists with the data needed to develop comprehensive models for the accurate prediction of global change. The first of these platforms, EOS-A, will focus on land mass observations, and NASA has recently identified the suite of instruments to be flown on them. It is imperative that the Committee support the Administration's FY'92 budget proposal for this first phase in order to continue the design and review of the instruments, the development of observatories, and development of long-lead components.

The second phase of Mission to Planet Earth, EOS-B, will carry instruments to concentrate on the oceans and the atmosphere. Because EOS is a long-term project and will not become available until late in the decade, and given the current fiscal environment, EOS should be funded on a "level-of-effort" basis, such as we outlined in our principle guidelines in our introduction.

A critical element of EOS is the Earth Observing System Data Information System (EOSDIS). It will be the "brains" behind EOS, consisting of Central Data Handling Facilities, a Data Archival and Distribution System, and an Information Management Center which will process, store and distribute the information obtained from the flight instruments. With programs such as EOS, NASA is entering a new era in which the large data collection capabilities of new satellites become extensive. But success cannot be achieved in this program merely by increasing launch frequency and reliability or by collecting large volumes of data. NASA must give increasing attention to assuring that the data collected are analyzed and converted into useful scientific information. For these reasons, EOSDIS is a critical element in understanding the Earth's environment and should be supported fully.

In addition to the large multidisciplinary EOS platforms, certain critical observations require unique orbits or sensor environments. The Earth Probes program addresses specific urgent problems such as ozone depletion, tropical rainfall monitoring, and monitoring of ocean winds and circulation. Earth Probe missions are also able to be built and launched quickly, filling gaps in our knowledge of global processes before the large platforms are on orbit. The modest growth in this budget item should therefore be strongly supported.

Programs that fly in concert, such as the EOS platforms and Earth Probes, enhance the scientific return of data and ensure a sound base of knowledge. This base will enable our decisionmakers to establish the economically significant policies that will need to be made on the major environmental issues we now face. Also, a renewed focus on smaller missions, as noted earlier, has important ancillary benefits to the scientific community in the education and training of younger scientists and engineers.

SPACE TRANSPORTATION

Space transportation is the keystone for a successful U.S. space program More dependable and economic access to space is essential, and the current U.S. mixed fleet of Shuttles and expendable launch vehicles (ELVs) must clearly be enhanced.

Because the Shuttle is our only operational manned vehicle and our largest-capacity launcher, and because it will therefore play a key role in all space activities for at least the next decade, it is necessary that it remain able to play that role. The Shuttle fleet should therefore continue to be upgraded to incorporate current technology that enhances system reliability and reduces operations costs. Failure to do so could preclude Shuttle availability and ground the U.S. manned spaceflight program long before a new operational system is available. Congress should continue its support of such Shuttle upgrade efforts.

The Advisory Committee stated that "the most significant deficiency in the nation's future civil space program is an insufficiency of reliable, flexible, and efficient launch capability." The AIAA too, has strongly urged the development of a new, lower-cost, operationally efficient space launch capability. Although the nation's currently approved space missions, both military and civil, do not by themselves require that new capability, the needs for space launch development are not mission-specific. A consensus of NASA, DOD, and the industry calls for the development of a new operationally efficient space launch capability to begin immediately.

The joint DOD,NASA Advanced Launch Development Program has focused on the technologies and system concepts needed for that capability. However, program funding in FY1991 was cut severely. Increased funding and a long-term national commitment to the development of a national launch system, which both the AIAA and the Advisory Committee have suggested should be based on the management, design, and operations philosophies of the earlier joint DOD-NASA Advanced Launch System, is needed. The initial increment of the development budget for such a system appears in the Administration's FY92 budget proposal (it is shared equally by NASA and the Department of Defense). Support of that budget is essential to the future health of U.S. space activity.

Derivatives of current launch systems continue to be considered based on the appeal of low development cost and early availability. But derivative vehicles offer little improvement in the processes of manufacture, integration, test, and operation. Such improvement is needed for low-cost, dependable space launch capability. The AIAA urges Congress to support space launch infrastructures that focus on efficient launch system operations rather than on performance-driven vehicles. Such capabilities can be obtained neither rapidly nor at low cost, but they must be developed if the nation is to move forward from today's R&D-like launch systems to efficient, dependable, world-competitive launch systems of the future.

Commercial needs for space launch are driven by low cost, flight reliability, and schedule dependability. Government investment in the technologies, systems, and infrastructure that are aimed at applying these features to civil and military requirements will also benefit commercial interests. Such government investment would stimulate additional private-sector investment and help improve U.S. commercial competitiveness in world launch markets.

Although the current emphasis for a new launch system is derived from the joint ALS program, and properly so, Congress should not ignore the valuable new technologies emerging from programs such as the National Aerospace Plane (NASP). The highly promising advancements in materials development, propulsion, and aerodynamics could be broadly applicable both to new space launch vehicles and to advanced commercial and military aircraft. The heavy foreign investments in hypersonic technology independent of NASP are evidence of the importance this technology seems to represent to our economic competitors.

SPACE STATION FREEDOM

As stated earlier, the budget pressures on Congress are enormous, making it difficult to authorize decades-long, multibillion-dollar programs such as Space Station Freedom. This process culminated last fall in a substantial reduction in Freedom's budget plans, and a Congressional request that NASA reconfigure the station accordingly. A main concern was the ability of the Shuttle to deploy and assemble Freedom. This mandate by Congress was reiterated and strengthened in December by the Advisory Committee. But although the revisions in Freedom's planning will certainly help to address current budgetary and engineering problems, the funding instability represented by this and previous rescoping exercises could compromise the integrity of the program and increase future costs. Freedom was identified by President Bush as the "critical next step in all our space endeavors." We agree. The station will serve as the testing ground for developing the technologies needed for human exploration of space and for immediate application in solving problems here on Earth. Permanent human presence at Freedom will provide invaluable data on the long-term effects of low gravity. And as the largest international space effort, Freedom provides a foundation for future international space activities.

During the past year Freedom was subjected to a succession of critiques addressing specific design issues, cost, and method of assembly. NASA has reacted positively, and has evolved a design and program plan to meet the changes mandated by Congress and suggested by the Advisory Committee. The program is now making the critical transition from preliminary design and review into development, hardware fabrication, and testing. Further delays will not only increase life-cycle costs; they will also delay the benefits that will accrue from early use of the station.

Our international partners will contribute nearly $8 billion to the program. Their costs grow by $200-$300 million per year for every year's delay in Freedom. Hence U.S. budget instability is of serious concern to them. Such instabilities have caused problems in the past, and will affect not only Space Station Freedom but potential future international cooperation efforts such as space exploration. Once NASA's redesign of Freedom has been established and accepted by Congress, therefore, it is important to proceed with completion of the station as expeditiously as possible, and for the Congress to provide the stable funding needed to do so.

One final point: the Advisory Committee's report recommended that Freedom's goals be limited to life science studies and microgravity research. Although AIAA has always emphasized the importance of these activities, it is necessary that some emphasis also be given to Freedom's important role in advancing, testing, and demonstrating infrastructure technologies, such as automation and robotics, innovative structural design and dynamics, and systems needed for on-orbit operations.

SPACE TECHNOLOGY ADVANCEMENT

As stated earlier, and as also emphasized by the Advisory Committee, technology is fundamental to all space activities. NASA currently has two focused programs underway to develop the hardware, software, design techniques, and data needed for future missions. The Civil Space Technology Initiative (CSTI) is developing technologies for efficient and reliable access to space, and the Exploration Technology Program will advance critical technologies in the areas of manned and robotic missions to expand human presence into space.

Both these programs represent NASA's effort to replenish the technology "bank" we have been depleting for the past two decades. There is no hope for pursuing major space exploration goals without future, consistent commitments to these technology efforts. We urge you to continue your support of both CSTI and Exploration Technology this year, along with other cutting-edge technology advancements such as those needed for the new launch system, for Freedom's laboratory facilities, and for materials processing.

We are particularly concerned about support for the key technology programs in the Exploration Technology budget that are aimed at reducing the development risk for future exploration initiatives. These include advanced life support, power, propulsion, and aerobraking. In addition, advanced technology developments in areas such as advanced sensors, autonomous operations, and enhanced redundancy and reliability of specific subsystems are essential to many future programs, not just piloted deep space missions. Aerobraking and automatic rendezvous and docking are also needed to expand our capability for robotic planetary investigations. Although years of research and development will be necessary to perfect these technologies, they merit attention now because they are relevant to many space activities, both human and robotic. Where multiple technology options exist, parallel technology advancement programs should be undertaken until a clear choice is indicated. Moreover, these programs must include progressive flight testing to focus the technologies through development, demonstration, and on to operational systems.

The proposed Life Sciences program is strong in its objective of understanding the relative benefits of artificial gravity vs. the development of countermeasures, and in its life support technology goals. Specifically, the Radiation Biology Initiative, also known as Lifesat, is a critical element in this objective. The Lifesat spacecraft will address the effects of space radiation on living systems and will have a significant influence on programs such as the space station and the Space Exploration Initiative which require long-duration stays in space. In addition, the psychological issues associated with prolonged exposure in a confined space must be given adequate attention.

These programs, as well as other life sciences projects, will have a crucial impact on any future human exploration efforts. It should be further emphasized that life sciences research requires as well as money. Only sequential, long duration microgravity and space radiation exposure tests can provide the necessary "ground truth" data for biological change models and countermeasure side effects. This research will likely pace any future piloted deep space exploration schedule. The Advisory

Committee recognized their importance as the "long pole in the tent" of human space exploration; they should be given high priority.

SPACE EXPLORATION INITIATIVE

It is difficult to justify endeavors like the Space Exploration Initiative (SEI) in strict cost-accounting terms. Many arguments for such a program have been aired: gaining scientific understanding, sustaining international leadership,reinvigorating public appreciation of scientific and engineering values, developing tomorrow's economic base, and furthering the human spirit by searching new frontiers. We all realize that these "returns" on our space investments will accrue over time spans measured in decades and centuries, not months and years.

We cannot possibly predict all the benefits that may accrue from any specific program of exploration and discovery. But history tells us that whenever a new frontier has been opened by mankind through the process of exploration the benefits have been profound—sociologically, scientifically, economically, and politically.

The SEI responds to mankind's basic need to explore, gives us the experience needed to learn how to travel and work in this new realm, stimulates the scientific and engineering curiosity of a generation of students, and opens new opportunities for peaceful international cooperation. We will learn more about how to operate in space just by building and assembling a space station than we have learned in all past history. By the very act of setting up an outpost on the Moon we will learn how to establish, manage, and operate a nonterrestrial base and use its resources. Developing and carrying out the missions needed to establish and sustain a permanent base on Mars will teach us how to expand further into the Solar System and, eventually, the Universe beyond.

To be successful, SEI will require increased efforts in space science and technology and a more complete understanding of how living systems react to the stresses of long-term space flight and the lunar and Martian environments. Before we can establish a lunar base or send humans to Mars we must have a better understanding of the physiological effects of long-duration space flight on the human body. The fundamental design concepts of spacecraft needed for very long manned flights depend on the results of life sciences studies such as those planned for Space Station Freedom.

The Administration's FY92 budget proposal is, we believe, overly conservative in its allocations for studies and technologies applicable to space exploration. Research on life sciences and technology advancements in propulsion and power require long lead times, and they are critical to any space exploration endeavor. Besides, these programs are also relevant to many space activities, not solely to human exploration of space. We join the Advisory Committee in urging you to increase the budgets for these studies, as well as for the entire Exploration Technology Program, or at the very least approve the Administration's limited request.

Moreover, if this nation is to embark seriously on long-term human exploration efforts, those missions must be developed methodically. Goals and objectives must be established at the outset and pursued in an orderly manner, with, of course, flexibility dictated by the evolution of technology. AIAA therefore recommends increasing the $15 million budget request for the mission studies needed to define an architecture on which to build. The outreach program the AIAA conducted for NASA this past year and the recommendations of the Synthesis Group in its forthcoming report provide valuable inputs to this process, but there is no substitute for the time and efforts of the scientists, engineers, and managers needed to devise and plan a workable, affordable exploration architecture and the systems to implement it. There is no free lunch; that time and effort must be paid for. We commend the recent recreation of an independent Office of Exploration in NASA, and urge you to increase, or at the very least support, the Administration's request for these critical studies.

Note that the timely initiation of architecture studies allows proper structuring of contemporaneous programs having strong interrelationships with the SEI. The national launch system development addressed earlier, for example, would be expected to evolve into an SEI payload delivery system, but SEI requirements are not yet well understood. Space Station Freedom, too, can play an important role in the SEI, but architecture studies are needed to define that role more specifically.

Because of the breadth of scope of the SEI, the President has recognized that other government agencies should also be involved, and that strong efforts are needed to encourage commercial participation. Congress should therefore explore new legislation to encourage private industry, including those sectors not traditionally associated with aerospace programs (e.g., medical, pharmaceutical, construction,

mining, etc.), to develop new skills applicable to SEI that will also improve their competitiveness in the international marketplace.

It is clear, however, that NASA is the only organization with the requisite technical and management capabilities to lead this effort, as recommended by the Advisory Committee. The Committee had also suggested that for long-term, "frontier-pushing" programs like the SEI, budgets should be set at an affordable annual level on the understanding that level will be sustained not just for the "out-years" of a specific project but on a continuing basis, and that the milestone accomplishments and schedules of an essentially open-ended program are keyed to that level. The previous approach, in which total programs were shoehorned into a fixed schedule and total fixed cost, with unpredictable technical problems addressed by budget overruns, is no longer either desirable or acceptable.

EDUCATION

The Space Exploration Initiative and the Mission to Planet Earth constitute a challenge to our nation today and in the years to come. The very nature of these programs requires a long-term, sustained commitment by those who inspired and initiated them and those who will follow in their footsteps. NASA will experience a high percentage of retirements within the next few years, and therefore must be given the flexibility and direction to rebuild a strong, capable, and competitive workforce both within NASA and among its supporting contractors. The recent establishment by the NASA Administrator of an Office of Human Resources is a key step in the right direction.

But simply rebuilding its current workforce isn't enough. NASA must prepare for the next century when programs like Mission to Planet Earth and the Space Exploration Initiative come to fruition, and begin preparing to meet the personnel needs they will engender. The people who will become our future scientists, engineers, and mathematicians are currently in elementary school. It is imperative that the nation plant the seeds of inspiration today in order to ensure the technically literate workforce needed to function in the high-technology world of tomorrow.

This will not be an easy task. Current studies of student capabilities show that the U.S. ranks low in the areas of math and sciences compared to other technically advanced countries. In addition, the United States graduates a smaller percentage of engineers (8 percent of total graduates) than Japan (20 percent of total) or the USSR (39 percent of total). Moreover, other countries are increasing the fraction of their labor force employed in science and engineering more rapidly than the U.S.

It is quite clear that U.S. technology leadership is being seriously threatened in an increasingly technologically dependent world. NASA's efforts to invigorate this vital educational issue with the establishment of the minority university research and space grant college and fellowship programs should be given maximum attention, and should be strongly supported by Congress.

But the efforts now being undertaken in the education industry, although valuable, cannot reverse the downward trend of the past two decades in mathematics, science, and engineering education. Additional support, including funding, will be required from both government and industry. Activities to improve education in these key areas could include employment of science and math teachers by aerospace companies during the summer, expanded programs of plant tours for students and teachers, proofreading and editing of science and math texts by aerospace professionals, assistance in curriculum development by corporate engineering and publication departments, regular volunteer classroom teaching by scientists and engineers on a released-time basis, after-school math and science tutoring, presentation of exciting up-to-date scientific achievements and concepts to parents and students (e.g., at PTSA meetings), and visits to the homes of talented but underachieving students.

AERONAUTICS

Aeronautics has long been one of the strongest sectors of our industry. The Department of Commerce estimates aerospace will record $113 billion in total sales for 1990 and a favorable trade balance in excess of $26 billion. Aeronautical products (aircraft, engines, missiles and related parts) dominate these sales. The continuing success of our aeronautics industry is due, in large part, to the long-term, constructive relationship that has existed in this area between government, industry, and academia. Congress has been an important part of this relationship by authorizing the funds necessary to build and maintain our aeronautics technology base.

Why is the aeronautics industry important to the United States?

The United States emerged from the aftermath of World War II as the leader of the industrialized world. American investments in manufacturing, technology, and science dramatically increased the world's standard of living. Until recently, America was second to none in productivity, creativity, and innovation. In science, the large number of US Nobel laureates testifies to US scientific leadership after World War II. However, we are beginning to recognize that scientific proficiency alone is not a guarantee of economic success. As a nation, we are becoming increasingly concerned about transitioning our national scientific expertise and assets into products competitive in the world market,

In 1970, the United States stood at the pinnacle of technological and industrial success with a trade surplus of $800 million.[1] No single, American achievement better characterized US technological prowess than the Apollo program. For many, this achievement was the zenith of American success.

The situation has changed. Europe and Japan have rebuilt their industrial base and technology is now a commodity on the world market, In February 1990, the President's Council of Economic Advisors reported that the United States' 1989 trade deficit exceeded $129 billion dollars. In 1989, the International Trade Administration reported that each billion dollars of exports supported over 22,000 jobs.[2] By inference, the cost of the United States trade deficit has been 2.8 million jobs. These jobs represent lost revenues, lost opportunities, and other hidden costs to society that we are unable to fully quantify.

Many of the major industries that typified American economic strength, such as automotive, shipbuilding, steel, electronics, and other technology-based industries, are posting trade deficits (Figure 1) Yet, in 1990 the United States will post an estimated trade surplus of $22 billion in the aerospace sector.[3] This trade surplus, the largest in the manufacturing sector, has a large generative power. This surplus generates tax revenues that support other programs throughout the government. Today, aerospace employs over 1.3 million men and women in the United States and employs one hundred and eighty thousand scientists and engineers.[4] US aerospace sales exceeded $123 billion in 1989 (Figure 2) and were of the same order of magnitude as automotives, and electronic equipment and electronic computing combined.[5]

Aeronautics has been at the heart of US success in aerospace, representing more than 60 percent of aerospace sales and over 95 percent of exports.[6] Today the United States supplies over 70 percent of the Western World's civil aircraft market. The rapid growth of the transport market has been fueled by deregulation, growing international travel stimulated by emerging economies, and other economic factors. The civil jet transport market alone is expected to be worth $1.5 trillion through the year 2030 (Figure 3).[7]

This US aeronautical leadership is the result of a cooperative relationship between industry and government that began with the formation of the National Advisory Committee on Aeronautics (NACA). NACA, the predecessor of the National Aeronautics and Space Administration, was formed in 1915 amidst concern that European aircraft manufacturers were surging ahead of US industry. NACA's pioneering research throughout all flight regimes has made important contributions to the areas of basic research and pre-competitive technology validation. Today, NASA continues to provide the R&T basis for major military and civil aeronautics advances.

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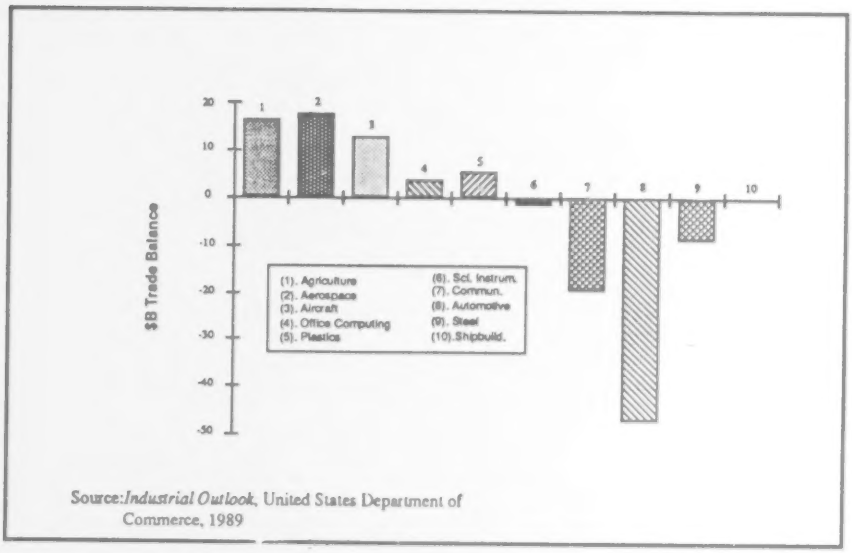
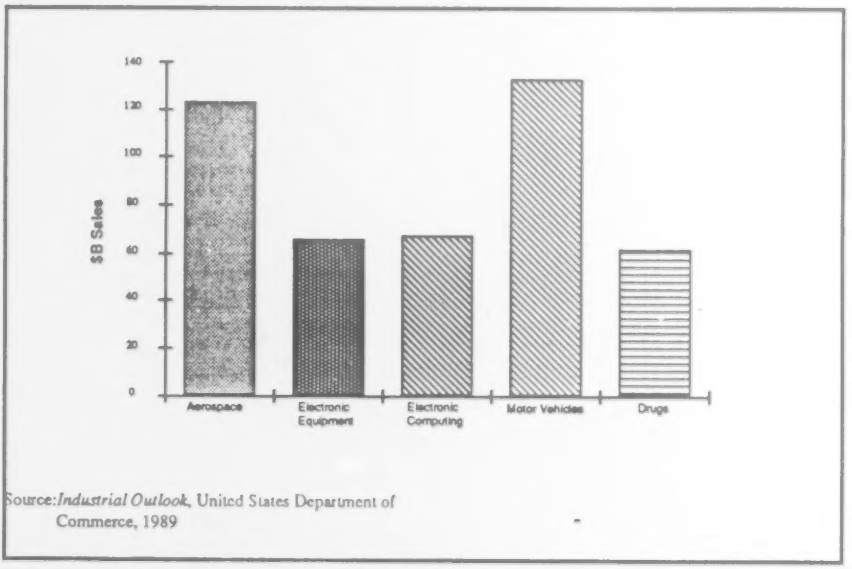
[1] *Economic Report of the President,* Council of Economic Advisors 1990, p. 406.
[2] *Ibid.*
[3] *United States Trade Performance,* Department of Commerce, 1988.
[4] *Aerospace Facts and Figures.*
[5] *Ibid.*
[6] *Industry Outlook,* Department of Commerce, 1989.
[7] *Aerospace Facts and Figures,* AIA.



Source: *Industrial Outlook*, United States Department of Commerce, 1989

FIGURE 1.—Aerospace Products, Including Aircraft, Are Large Positive Contributors to the United States Balance of Trade.



Source: *Industrial Outlook*, United States Department of Commerce, 1989

FIGURE 2.—Aerospace Is One of the Largest Sectors of United States Manufacturing.

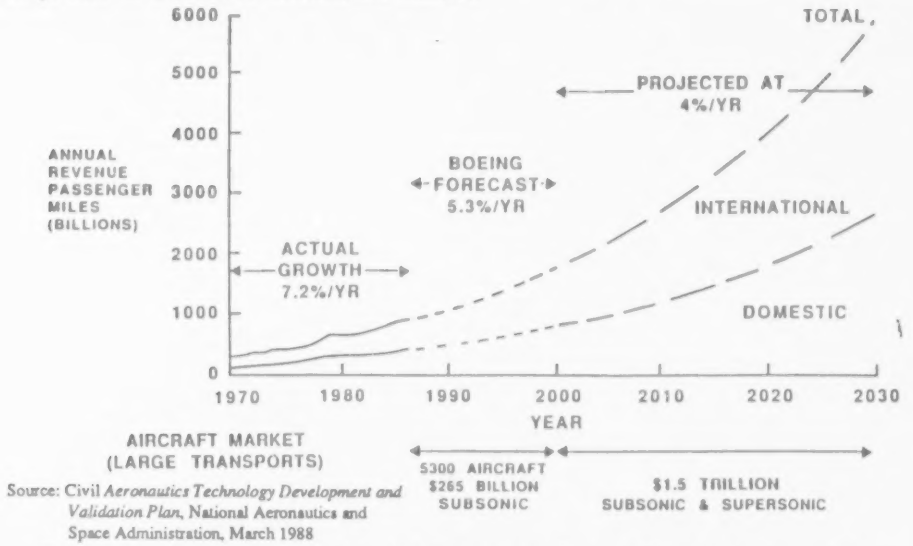
Other nations have recognized aeronautics as not only a technology driver but as a strong factor in international trade and prestige. Like the United States, these nations have established policies to foster aeronautical research. As an example, agencies such as the French ONERA and the German DPVLR conduct aeronautical research and maintain and operate first-class aeronautical research facilities.[8] This focus on capturing the large market in aeronautics has resulted in the development of first-class research facilities in Europe and Asia. Phil Condit, Chairman of NASA's Aeronautics Advisory Committee recently said that the United States' high

[8] *Civil Aeronautics Technology Development and Validation Plan*, NASA, 1988.

speed wind tunnels are a "Close no. 2" to British and French facilities. As a result Europe now produces equipment technologically equivalent, and in some cases superior, to US products.

In addition, foreign governments, unlike the United States, act as financial risksharing partners in commercial product development. The success of the Airbus Industrie consortium would have been impossible without the direct participation of the four key European governments. Airbus is expected to capture 30 percent of the commercial jet transport market by the year 1994. The head of Deutsche Aerospace GmbH, Juergen Schrempp, doubts "* * * that the Airbus consortium would have survived if privately run from the start * * *"[9] The Federal Republic of Germany (FRG) has taken other steps to ensure the strength of the giant Deutsche Aerospace. The FRG has agreed to guarantee exchange rate losses for Deutsche Aerospace in the event of unfavorable dollar fluctuations against the West German Deutsche Mark, as part of the "sweetener" to encourage last year's merger between Daimler-Benz and MBB. As part of the same merger package, the Kreditanstatt fur Widerafbau (the West German credit bank to reconstruct the West German economy after World War II) became a 20 percent owner of Deutsche Airbus, the West German component of Airbus Industrie.[10] The government of the Federal Republic of Germany actively encouraged the formation of Deutsche Aerospace GmbH under Daimler-Benz, an aerospace giant with over 55,000 employees and annual revenues in excess of $7 billion.

A cooperative agreement reached between Daimler-Benz and Mitsubishi Heavy Industries of Japan is expected to bring the strong technical, management, and financial resources of the two companies to bear on the aerospace sector. With the experience that will be gained by the opening of a second Airbus A-321 assembly line in Hamburg and the vast financial resources available to Deutsche Aerospace and Mitsubishi Heavy Industries, such a partnership could become a formidable competitor in the future aeronautics market.



Source: Civil *Aeronautics Technology Development and Validation Plan*, National Aeronautics and Space Administration, March 1988

FIGURE 3.—Civil Transport Market Projections Reflect Worldwide Growth in Passenger Traffic.

Since the United States does not have the competitive advantages of low capital costs and low labor costs, our trade advantages have traditionally been in the high-tech sector. But even our high-tech trade balance has declined sharply (Figure 4), except for aerospace (and especially aeronautics), which continues to show a large trade surplus.[11]

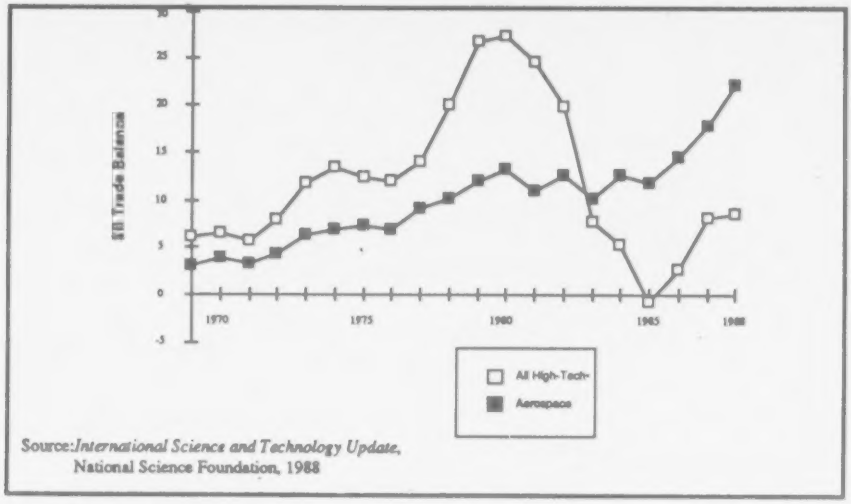
But we are beginning to see early signs of the erosion of our technology advantage in aeronautics, too. Patents have long been considered precursors of future industrial competitiveness, and the percentage of aeronautical patents granted to US au-

[9] *Office National d'Etudes et de Recherces Aerospatiales* (ONERA) and *Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raufahrt* (DFVLR).

[10] *Aerospace Daily*, May 21, 1990, p. 298.

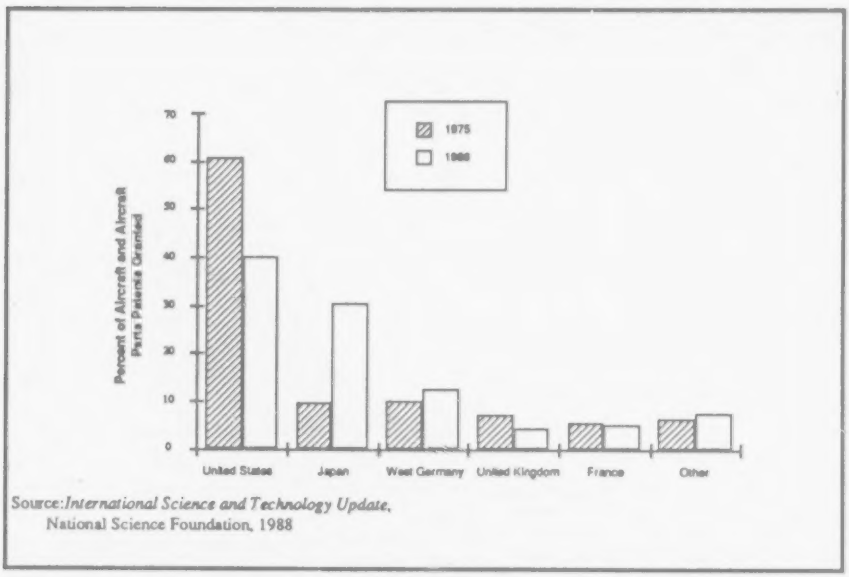
[11] *Aviation Week and Space Technology*, Jan. 29, 1990, p. 77.

thors has declined dramatically in the last fifteen years. In 1975, the United States received 60 percent (428) of the aeronautical patents granted, and Japan received nine percent. In 1983, the United States received only 40 percent (327) of the patents granted in aeronautics, and Japan received 30 percent (249) (Figure 5).



Source: *International Science and Technology Update*, National Science Foundation, 1988

FIGURE 4.—Aerospace Balance of Trade Counters High-Tech Trend.



Source: *International Science and Technology Update*, National Science Foundation, 1988

FIGURE 5.—United States Aircraft and Parts Patents Are Decreasing.

The AIAA believes that aeronautics can continue to be the well-spring of US technological and industrial competitiveness well into the 21st century. But this success can only be assured by a reinvigoration of the successful industry-government partnership that has characterized American aeronautics.

The role of technology validation and flight research

The U.S. built a significant lead in the aeronautics field between World War II and the late 1970's. To a large extent, this lead was achieved by recognition of the need for a vigorous flight research program. Wind tunnel and computational methods have greatly improved our capability to design high-performance aircraft. Advanced, experimental methods used with ground test facilities have greatly enhanced our ability to quantify new phenomena. Sophisticated simulation techniques that include pilots as part of the system have enabled us to develop and test advanced control laws. However, these techniques must be supplemented by a vigorous flight research and technology validation program. Flight research vehicles are needed to:

- Identify new phenomena and reduce uncertainties, especially when extending the flight envelope,
- Fill the gap created by ground test facilities which do not cover the entire flight regime,
- Focus and accelerate the development of advanced technologies,
- Validate the integration of one, or multiple, advanced technologies into an aircraft system, and
- Validate new design Concepts.

A vigorous flight research and technology program is essential to maintaining a strong national defense. The Current X-29 (Forward Swept Wing), the X-31 Enhanced Maneuverability Demonstrator, and the future X-30 National Aerospace Plane represent a significant continuation Of this valuable activity. Flight research vehicles in this class have been responsible for discovering almost all known dynamic phenomena relating to aircraft stability and for demonstrating advanced control laws and systems that permit flight beyond normal, statically-stable limits. The X-29 flight program, for example, has demonstrated performance levels (associated with the integration of several advanced technologies) that were not predicted by analysis or wind tunnel tests. In some cases, these hoped-for performance gains were ridiculed before the actual flight tests.

Most important aerodynamic advances today require the integration of several discrete technologies into systems with entirely new characteristics. For instance, advanced control laws, control system components, and thrust-vectoring exhaust nozzles are combined to extend the limits of maneuverability in the High Angle-of-Attack Research Vehicle (HARV). When emerging technologies such as these are integrated into a new system, they must be validated as a system in a realistic flight environment. Modified vehicle components such as advanced wings, engines, and other subsystems applicable to advanced subsonic and supersonic aircraft can only be fully explored and validated within the constraints of a functioning, integrated system. New civil aircraft concepts that show promise for reducing airport congestion and increasing air system capacity will need to undergo rigorous concept evaluation and flight validation before the risk can be reduced to the level that will make such concepts viable options.

NASA must be able to conduct this pre-competitive technology evaluation and flight validation effort in order to fully implement its aeronautics charter. There is need for an energetic pursuit of significant experimental and technology verification flight vehicles in order to provide militarily superior aircraft and economic and efficient commercial transportation, thereby retaining the pre-eminence of U.S. aeronautics technology.

OVERVIEW OF SPECIFIC NASA AERONAUTICS PROGRAMS

NASA has proposed a FY92 budget of $1,029.1M for aeronautics-related efforts. This includes $591.2M for the R&D program, plus the associated $386.3M for Research and Program Management (R&PM), and $51.6M in the Construction of Facilities (CofF) accounts for facility modernization. This represents a growth of 12 percent, with the importance of the R&D program being recognized by a nominal 15.5 percent increase. In addition, there is a proposal for NASA work related to the National AeroSpace Plane (NASP) for $72M in FY92, down from $95M.

If one considers just the R&D accounts, then this FY92 total of $663.2M for the combined Aeronautics R&D plus NASP represents just 9.2 percent of NASA's total R&D budget proposal, down from 10.1 percent last year. Further, the Aeronautics R&T accounts include $ 15M for High Performance Computing and Communication (HPCC) that was reprogrammed in FY91 and continues in FY92, but which was taken from previously planned and authorized aeronautics efforts. Discounting the $663.2M budget for the $15M reallocation to I1PCC, leaves $648.2M, or 9.0 percent of NASA's budget for program areas traditionally identified as "aeronautics."

Noteworthy achievements and plans for each of the program areas will follow. The proposed budget for each category is shown along with a percent increase from last year.

The research and technology base

NASA has proposed a budget increase from $336.4M to $375.6(11.6 percent) for the Research and Technology Base (R&T) related to aeronautics. The AIAA continues to support NASA in its role of providing for the advanced aeronautics technology needed to assure the technological superiority of future U.S. aeronautics aircraft and systems. This is a vital role for NASA, one which if neglected would not be adequately addressed by any other federal agency or by private enterprise. The aeronautics industry has a singularly long time scale from the identification of new technological capability to its application in civil or military aerospace products. Because of this time-frame, and the associated financial and technical risks, it is an appropriate and necessary role for our government, through NASA, to be integrally involved in conducting and sponsoring basic and applied research in the aeronautical sciences.

Aerodynamics R&T

Our ability to improve aeronautical designs is increasingly dependent on our ability to accurately model the complexities of fully viscous, three-dimensional flows in several flow regimes. NASA's aerodynamics R&T places an appropriately strong focus on improving our understanding and modeling capability for such flows. It continues, where appropriate, to validate new aerodynamic concepts which can be applied to improved designs. An important example of NASA's efforts is the experimental flight evaluation of hybrid laminar flow control for reducing drag on subsonic aircraft wings. Other experimental and analytical work on the complex flowfields, noise and structural interactions of rotorcraft and STOVL[12] is also conducted under this program area.

In FY92 NASA will continue to work in these areas with special emphasis on transition phenomena in boundary layers, which can lead to improved, low-drag, laminar-flow airfoil designs. NASA will to continue work in the area of complex interactions between flowfields, the aircraft structure, and (when present) ground effects. These studies are important to increasing structural life, reducing noise and increasing aircraft performance. NASA also plans to initiate work in airframe/propulsion system integration for high speed aircraft.

The AIAA supports the basic thrust of the Aerodynamics R&T program and the specific program elements it addresses, especially the efforts aimed at subsonic and supersonic drag reduction.

Propulsion and Power R&T

Whereas the Aerodynamics R&T deals primarily with the air vehicle, the Propulsion and Power R&T program area addresses key technologies for the propulsion systems. NASA's propulsion research is focused on developing and validating advanced CFD codes applicable to the internal flow through engines and On advanced concepts for propulsion systems components.

A major continuing area of emphasis is on an analytical tool for multistage axial compressors. Achieving gains in compressor performance is one of the most challenging and expensive development tasks in any new engine program. NASA's code development could provide industry with an important new design tool. NASA also will continue efforts to develop improved, low-emission combustion systems for subsonic applications and new approaches for supersonic combustion.

AIAA believes that there are still major gains to be made in gas turbine propulsion for subsonic aircraft, and that propulsion system advances are absolutely critical to achieving our goals for supersonic and hypersonic aircraft. Accordingly we support the Department of Defense program known as IHPTET,[13] of which NASA is one of the sponsors, as well as NASA's increased emphasis on Propulsion and Power.

Materials & Structure Technology

Materials and structures technology emphasize both the development and characterization of new materials and the necessary new design-analysis methods for utilizing those materials. NASA has had a strong program in this area for several years, and this work is increasingly important to application and development of advanced composite material systems. These composites are one Of the critical, crosscutting technologies identified on almost every critical technology roadmap as vital

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[12] *Ibid.*

[13] *International Science and Technology Data Update,* National Science Foundation, 1988.

to achieving lighter-weight, more-durable, higher-temperature aircraft and engines. Further, composite materials will have broad application in many other industries' products.

The AIAA strongly supports continuing this work (as well as the allied Materials and Structures work under Systems Technology Programs) with the goal of enabling the broad application of composite materials to future aircraft structures and engine components.

Controls, Guidance, and Human Factors

NASA's work on controls, guidance, and human factors concentrates on technology issues which can have major payoffs in improved safety and operational effectiveness of air traffic management. The 1988 report of the OSTP APRC[14] stated that the most pressing issue facing the aeronautics community was global air traffic control. This concern was the result of the rapid increase in global air travel and the strains this is placing on worldwide system capacity. This is a responsibility shared by NASA and the FAA, which are cooperating in this research area. Technology exists which, if validated, can have major impacts on improving the safety and capacity of our national and international air transportation system. Recent successful demonstrations by NASA such as instrumentation to detect atmospheric microbursts, and use of aircraft GPS[15] data to control landing separations, are excellent examples of what can be achieved.

AIAA supports NASA's continuing efforts on advanced controls, sensors, flight management technology, and cockpit automation. Systems and strategies to detect and survive hazardous flight conditions should receive priority attention. Optimal controls and advanced cockpit technology integrated with air-traffic controls should be pushed on a rapid timetable to mature and implement this technology.

Flight Systems R&T

Flight systems research addresses important realities of the flight environment (such as icing), complex flowfields (like high-angle of attack flight), and system integration effects (such as transition between modes for STOVL aircraft). The work is a challenging combination of analytical modeling, innovative configurations and difficult ground and flight experiments.

FY92 programs will focus on these same three subjects: icing phenomena, high angle-of-attack flight, and STOVL. AIAA recognizes that NASA has a long tradition and unique capability in this area which must continue to be exploited for the benefit of our national aeronautics program. At the same time, we wish to enter the observation that much of this program is relevant primarily to military aircraft.

Systems Analysis

The systems analysis program element, though small, is important because it provides much-needed quantitative evaluations of potential areas of research. The program provides guidance concerning which concepts and technologies have the highest potential payoffs. AIAA concurs with NASA's plans to continue this effort at the proposed level of effort.

Systems Technology Programs

Every report of the OSTP Aeronautical Policy Review Committee stressed the importance of technology validation and called for increased effort in this area of R&D. In 1985 they said,

> "The utmost critical area is technology validation, * * * National policies and implementing procedures * * * have driven unintended barriers into this critical mid-phase of R&T, causing this vital link in the innovation chain for aeronautics to be short-circuited."

In 1987, the APRC said,

> "Technology validation is currently the weak link in the R&D chain. Validation enables designers to incorporate new advances into a product with confidence in its performance, integrity and certificability. It is the longest and most expensive stage in advancing new technology. It is also the point where U.S. R&D momentum has become most vulnerable."

In 1988, the report read,

> "As a result, several important subsonic technologies have not been sufficiently validated for incorporation into commercial aircraft development programs at acceptable levels of risk."

As one of the responses to these messages, in 1987 Congress directed NASA "to prepare a multi-year technology development and validation plan that will help the

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[14] Short Take-off Or Vertical Landing.
[15] Integrated High Performance Turbine Engine Technology.

United States retain its leadership in aeronautics research and technology and compete in the international marketplace for future civil aircraft."[16] Much of the NASA Systems Technology Program that we are reviewing comes from that planning effort. The AIAA concurs strongly with the conclusions Of the APRC and with the direction of Congress in this matter. We have reviewed the 1988 Civil Aeronautics Technology Development and Validation Plan prepared by NASA and fully support its major thrusts.

We are pleased to see the growth in the Systems Technology budget area over the last few years, and we would like to encourage both the Administration and Congress to continue building up this area so that we can more effectively transition the investment in basic R&D to a state of development within reach of industry.

Comments on the specific Systems Technology" Programs follow:

High-performance computing

The AIAA commends the Administration and Congress for their roles in encouraging and supporting the High Performance Computing and Communication program, and for NASA's key leadership role in advanced software. These efforts are important to the nation and will have broad payoffs to the nation's technological competitiveness, including aeronautics. It is also important to recognize that while NASA's efforts on this program are recorded under Aeronautics Research and Technology, the planned HPCC effort represents a dilution or deletion of aeronautics effort. Although some advanced CEO algorithm development is planned under this program, the emphasis is on systems software for massively parallel computers.

Materials & Structures Systems Technology

This area of work will focus on the design and fabrication technology required to apply advanced composites to major aircraft parts and engine components. Rather than work at the coupon level, as is done in the technology base area, this effort will design and fabricate large-scale structures. Included in the plans are basic aircraft structural elements such as wing boxes and fuselage panels.

Advanced composites are an area receiving world-wide attention. Japan and France have massive programs and significant capability in composite materials. These "designer materials" will require a totally new, integrated approach to design and fabrication. They offer the potential for massive weight savings if efficient fabrication techniques can be developed and if it can be demonstrated that composite materials will hold up under actual service conditions.

NASA's augmentation in this area, supplementing and extending the materials and structures technology base, is strongly supported by the AIAA. NASA's program in this area appears exceptionally well-planned and comprehensive, except that there is no mention of improving Non-Destructive Examination (NDE) methods for composites.

Rotorcraft Systems Technology

Most of NASA's effort on rotorcraft is funded in the Technology Base area, rather than in this program element; although the total is only $25.3M. The United States' helicopter industry has steadily lost ground to foreign competition and now has a minority share of the world market. AIAA sees significant market opportunities for technically-superior rotorcraft and would like to see this category increased.

The work that is proposed under this program element is aimed at addressing noise reduction efforts and other certification issues for tilt-rotor aircraft. Considering the important domestic and international market that has been forecasted for a successful civilian variant of the V-22, and the relief such a system could give to some of our airport congestion problems, we would recommend this as a program which should be accelerated.

High Performance Aircraft Systems Technology

This program area appears to be primarily an augmentation of the Flight Systems base R&T program, allowing increased effort on technologies applicable to advanced military aircraft, and it has been responsible for evaluating the feasibility and merit of thrust-vectoring concepts for highly maneuverable aircraft and several advanced flight controls. Along a different avenue, one of the efforts planned for FY92 is the evaluation of supersonic laminar flow possibilities that would have applicability to both military supervise aircraft and a new civilian high-speed transport. The AIAA endorses these efforts at the planned level of effort.

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[16] Report of the Aeronautical Policy Review Committee, J.E. Steiner, Chairman, to the Office of Science and Technology Policy, August 1988.

Advanced Propulsion Systems Technology

The Advanced Turboprop Systems element concentrates on the ultra-high bypass engine. The technical work seeks to develop an integrated design and analysis capability for the aerodynamic, structural and acoustic performance of ducted propellers. Experimental work will be used to verify noise levels and investigate noise reduction and cancellation approaches.

The General Aviation Commuter Engine Technology program aims at improving smaller-sized engine components appropriate to applications in this market. Specific programs address advanced combustion technology and radial-flow turbomachinery.

Both of these program elements can lead to incremental improvements in propulsion systems, but the level of effort is insufficient to produce major advances.

Numerical Aerodynamic Simulation (NAS)

The NAS, and the research environment which surrounds it, is conducive to exploring innovative approaches to major problems in computational fluid dynamics. The work done is often First-of-its-kind demonstrations that could not be conceived or executed on machines with less computing power. AIAA applauds and supports the continuing contributions of NASA's Numerical Aerodynamic Simulation program.

High-Speed Research

The High-Speed Research program is clearly, and appropriately, the showpiece of NASA's Systems Technology Programs. This technology could set the stage for a next generation High-Speed Civil Transport (HSCT) with major international market opportunities. Over the next four decades, the most rapid growth in passenger traffic will be for intercontinental, over-water routes. Market studies show that an environmentally-sound and economically-competitive HSCT could capture a significant fraction of the commercial transport market estimated to be worth $20-50 billion per year. The potential of this market is not lost on our international competitors. Europe and Japan have initiated well-funded programs aimed at this opportunity.

For these reasons, the OSTP Aeronautical Policy Review Committee recommended accelerated pursuit of the enabling technologies: supersonic laminar flow, thermoplastic and metal-matrix composites, and supersonic through-flow and variable-cycle engines. They also recognized that environmental feasibility must be established. Further, they recognized that the scope and importance of this effort probably requires and justifies a consortium of U.S. manufacturers to design and produce this system.

AIAA concurs with the importance of this opportunity and the need to accelerate our technology efforts in that direction. For that reason, we strongly endorse NASA's emphasis on High-Speed Research. The first phase of the HSR program addresses the significant environmental issues: emissions, noise (airport), and sonic boom. The program has produced encouraging preliminary results that indicate that the emissions and community noise problems can be successfully resolved, although much more work is clearly needed.

During FY92, effort would be initiated also on advanced materials needed for the high-temperature combustion and exhaust systems needed to achieve low NO_x emissions and low noise. In the near future, these component concepts will need experimental verification.

Advanced Subsonic Technology

This effort was planned as a program augmentation to speed up efforts aimed at increasing the safety of existing aircraft, to demonstrate technologies that would allow increasing airport capacity and to provide advanced wing design and control system technologies needed for international competitiveness. This program was a primary goal of the Aeronautical Policy Review Committee Reports.

Because of budget constraints, the Administration has only submitted the fleet safety and advanced fly-by-light/power-by-wire FBL-PBW) controls for FY92 and has elected to defer airport capacity enhancement technologies and integrated wing designs at this time. Although AIAA recognizes the reality and desirability of constraints on the federal budget, we regret the deletion of these program elements. Given the already evident airport congestion, forecasts for growth in traffic, and the time delay before any proven technology can be implemented on a national scale, we should not delay any work on promising technologies that could help alleviate these problems. Similarly, given the immense size and economic importance of the subsonic commercial transport market and the technical challenges and market goals of our European competitors, we should proceed aggressively with any technology applicable to this class of aircraft.

How Can NASA Contribute to the Health of the Industry

Since 1915, the United States' national policy has called for leadership in aeronautics. The role of ensuring this lead was first assigned to NACA and then to its successor, NASA. Other governmental agencies make contributions, but their roles are minor by comparison. An integral part of this national policy is the pursuit of technology and its application. NACA's independent approach to fundamental research created the synergism that sparked U.S. aeronautical supremacy in wartime and preeminence in peace.

During the 1950's, NACA and DoD developed the axial flowjet engine and the swept wing. These technologies were the foundation of a new generation of aircraft that revolutionized public transportation and ensured three decades of U.S. dominance in commercial aviation. A significant development in the 1960's was the high-bypass-ratio turbofan engine. This concept more than doubled takeoff thrust, improved fuel consumption, and reduced engine noise appreciably. Similar opportunities for advances still exist.

In 1958, when NACA was absorbed into NASA, the character and substance of U.S. aeronautical research was affected. Emphasis was placed on space priorities while funding and manpower for aeronautics declined. Though U.S. aircraft still maintain a broad technological advantage, the margin of that advantage has narrowed dramatically.

Foreign governments have implemented policies to capture a greater share of the aeronautical market. Their technologies are now comparable, if not superior, to those of the US in some areas. The direct support foreign governments give to their industries goes beyond fundamental research and technology validation and involves financial underwriting of product programs.

Competitiveness in the international market is the result of many factors. These factors include design concepts that meet airline requirements, superior manufacturing capability and capacity, cost-effective processes, access to capital, fair competition, and technology readiness for safety and economic utility.

The full R&D cycle can be viewed as a chain of events leading to production: basic and applied research, technology validation, and product definition and development. NASA's historical role is research and technology validation. It is industry's role to define market needs, to conceive products, and to develop and incorporate technology into products.

Technology validation is the critical link between NASA and industry efforts. Recent budgetary constraints have severely curtailed NASA's efforts in technology validation. Future advances in aeronautics require a more aggressive NASA effort in technology validation as well as research.

NASA's budget should reflect the contribution that commercial aeronautics makes to the U.S. economy and balance of trade. The US aerospace industry depends on the continued use of advanced technology, and this technology has its roots in the research performed by NASA. Technical superiority will be difficult to achieve by either the U.S. or our competitors. Technical inferiority, on the other hand, is as simple as believing there is no threat and investing accordingly.

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